BMJ Open

An interview study of the experiences of cellulitis diagnosis amongst health care professionals.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-034692
Article Type:	Original research
Date Submitted by the Author:	02-Oct-2019
Complete List of Authors:	Patel, Mitesh; University of Nottingham, ; Lee, Siang Ing; University of Nottingham, Nottingham, UK, Division of Primary Care & National Institute for Health Research, School of Medicine, Levell, Nick; Norfolk and Norwich University Hospital NHS Foundation Trust, Dermatology Smart, Peter; University of Nottingham, Nottingham, UK Kai, Joe; University of Nottingham, Nottingham, UK Thomas, Kim; University of Nottingham, Centre of Evidence Based Dermatology Leighton, Paul; University of Nottingham, Centre of Evidence Based Dermatology
Keywords:	DERMATOLOGY, Adult dermatology < DERMATOLOGY, Infectious diseases & infestations < DERMATOLOGY, QUALITATIVE RESEARCH

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Title: An interview study of the experiences of cellulitis diagnosis amongst health care professionals.

Running head: Cellulitis diagnosis by health care professionals

Word count: 3994

Table count: 3

Figure count: 1

Supplementary materials: Figure 1

Authors: M Patel, [1,2] S I Lee, [1] NJ Levell, [3] P Smart, [4] J Kai, [1] KS Thomas, [2] P Leighton, [2]

[1] Division of Primary Care & National Institute for Health Research, School of Medicine, University of Nottingham, Nottingham, UK

[2] Centre of Evidence Based Dermatology, University of Nottingham, Nottingham, UK

[3] Dermatology Department, Norfolk and Norwich University Hospital NHS Trust, UK

[4] Patient representative, Centre of Evidence Based Dermatology, University of Nottingham, Nottingham, UK

ORCID ID: M Patel (0000-0003-3975-4689), SI Lee (0000-0002-2332-5452), NJ Levell (0000-0003-3393-8305), J Kai (0000-0001-9040-9384), KS Thomas (0000-0001-7785-7465), P Leighton (0000-0001-5208-0274),

Corresponding author: Mitesh Patel, Division of Primary Care, School of Medicine, University of Nottingham, Nottingham, UK, Email: mpatel59@doctors.org.uk

Funding sources: This study was supported by the Scientific Foundation Board of the Royal College of General Practitioners (grant SFB 2018 – 31).

Study registration: Centre of Evidence Based Dermatology website - https://www.nottingham.ac.uk/research/groups/cebd/documents/researchdocs/protocol-diagnosing-lower-limb-cellulitis-health-care-professionals.pdf

Abstract

Objectives: To explore health care professionals (HCPs) experiences and challenges in diagnosing suspected lower limb cellulitis.

Setting: UK nationwide.

Participants: 20 qualified HCPs, who had a minimum of two years clinical experience as a HCP in the national health service and had managed a clinical case of suspected cellulitis of the lower limb in the UK. HCPs were recruited from departments of dermatology (including a specialist cellulitis clinic), general practice, tissue viability, lymphoedema services, general surgery, emergency care and acute medicine. Purposive sampling was employed to ensure that participants included consultant doctors, trainee doctors and nurses across the specialties listed above. Participants were recruited through: national networks,

HCPs who contributed to the cellulitis priority setting partnership (PSP), UK Dermatology Clinical Trials Network, snowball sampling where participants helped recruit other participants, personal networks of the authors.

Primary and secondary outcomes: Primary outcome was to describe the key clinical features which inform the diagnosis of lower limb cellulitis. Secondary outcome was to explore the difficulties in making a diagnosis of lower limb cellulitis

Results: The presentation of lower limb cellulitis changes as the episode runs its course. Therefore, different specialties see clinical features at varying stages of cellulitis. Clinical experience is essential to being confident in making a diagnosis, but even amongst experienced HCPs, there were differences in the clinical rationale of diagnosis. A group of core clinical features were suggested, many of which overlapped with alternative diagnoses. This emphasises how the diagnosis is challenging, with objective aids and a greater understanding of the mimics of cellulitis required.

Conclusion: Cellulitis is a complex diagnosis and has a variable clinical presentation at different stages. Although cellulitis is a common diagnosis to make, HCPs need to be mindful of alternative diagnoses.

Keywords: lower limb, cellulitis, diagnosis, health care professionals

Article summary

Strengths and limitations of this study

- Two independent coders following a standardized codebook.
- Participants were included nationally around the UK, across various specialities that commonly diagnose cellulitis, with both nurses and doctors of varying clinical experience.
- Some participants were unable to fully describe their clinical rationale behind diagnostic decisions during the interview.
- Interviewees may not have fully shared the details of cases that were misdiagnosed or where diagnoses were delayed due to social desirability bias or fear of litigation.

Introduction

Cellulitis is a frequent presentation in both the community and secondary care, with 60% of presentations affecting the lower limbs.[1] However, the diagnosis of cellulitis can be challenging, with up to a third of suspected lower limb cellulitis cases being later diagnosed as other diagnoses.[2] This is further compounded by the lack of validated diagnostic criteria or tools for cellulitis.[3]

A UK cellulitis research priority setting partnership (PSP) determined that improving health care professionals' (HCPs) diagnostic accuracy is a key priority for future cellulitis research.[4] An interview study of people with recurrent cellulitis and lymphoedema suggested that patients often

experience difficulties in obtaining a speedy and accurate diagnosis (accepted by British Journal of General Practice).

The aims of this interview study was to explore the HCP experiences and challenges faced in diagnosing suspected lower limb cellulitis.

Methods

Protocol registration and Ethics

The final protocol was registered on the Centre of Evidence Based Dermatology (CEBD) website (9 May 2019). Ethical approval was granted by the Health Research Authority and Health and Care Research Wales (19/HRA/0485) (30 November 2018). Verbal and written consent was obtained from each participant.

Patient and public involvement

The research question was developed from research priorities in the cellulitis PSP, involving patients. A patient representative helped design this study and is a co-author. On publication, participants will be sent the final manuscript.

Eligibility criteria

Selection of participants

Participants were qualified HCPs, who had a minimum of two years clinical experience as a HCP in the national health service (NHS) and had managed a clinical case of suspected cellulitis of the lower limb in the UK. HCPs were recruited from departments of dermatology (including a specialist cellulitis clinic), general practice, tissue viability, lymphoedema services, general surgery, emergency care and acute medicine.

Purposive sampling was employed to ensure that participants included consultant doctors, trainee doctors and nurses across the specialties listed above. Participants were recruited through:

- National networks
- HCPs who contributed to the cellulitis PSP
- UK Dermatology Clinical Trials Network
- Snowball sampling where participants helped recruit other participants
- Personal networks of the authors

Data collection and analysis were undertaken concurrently and sampling ceased when thematic saturation had been achieved (i.e. new interviews generated no new insights).

Researcher characteristics

Interviews were conducted by MP, and coded and analysed by MP and SIL (both general practitioner (GP) trainees). The broader research group included experienced clinical-academics (JK and NL), a patient representative (PS), and qualitative experts (JK and PL).

Interview setting

Each participant took part in a single, semi-structured, qualitative interview. These were either face-to-face or via telephone, according to participant preference. All participants received a £20 reimbursement voucher or donated this fee to the British Skin Foundation charity.

Data collection

Prior to the interview, participants were asked to reflect upon their most recent experiences of making a cellulitis diagnosis, focusing on the typical presentations, challenging cases and differential diagnoses.

A topic guide, informed by a prior systematic review and interview study,[5] was used to structure the interview (Supplementary materials, Figure 1). However, participants were urged to propose and/or expand on topics which they felt were relevant to their experience of diagnosis.

Data processing

Interviews were audio-recorded and transcribed. Transcripts were checked (by MP) and data managed using QSR NVivo 12 software.

Data analysis

Analysis was inductive, searching for themes in the data. A structured, systematic, multi-stage approach to thematic analysis was followed. [6]

Data were coded independently by MP, with SIL also independently coding a third of the transcripts. Uncertainties in coding and thematic organisation were resolved in discussion with the other authors. Data collection and analysis was concurrent. The final codebook was agreed by all authors and is presented in Figure 1.

Results

Twenty HCPs were interviewed (Table 1). Interviews were conducted between 19 March and 11 June 2019.

Table 1: Characteristics of the participants

Characteristics	Number of participants, n
Gender	
Female	15
Male	5
Age	
25-34	4
35-44	8
45+	7
Ethnicity	
White	13
Asian	5
Black	1

Mixed	1
Specialty and clinical role	
Dermatology	5
Consultant/Trainee/Nurse	3*/1/1
General practice	6
GP/Trainee/Advanced Nurse Practitioner	4** (one locum)/1/1
Emergency care consultants	2
Acute medicine consultants	2
Infectious disease consultant	1***
Lymphoedema nurse	1
General Surgery trainee	1****
Tissue Viability nurse	1
District nurse	1
*One subspecialises in lymphoedema ** One subspecialises in dermatology *** Also works in acute medicine **** Also worked as an emergency care locum	
Years of clinical experience	
<10	6
11-20	9
20+	5
Number of times the HCP diagnosed lower limb cellulitis	
11-50	6 (30)
50+	14 (70)
Time since the HCP last made a diagnosis of cellulitis	
<1 month	16
1-6 months	3
6+ months	1

178

Main findings

Four key themes were identified: 1) The patient presentation; 2) Challenges leading to diagnostic uncertainty; 3) Strategies to improve diagnosis; 4) The need for an objective diagnostic aid, with further classification into sub-themes. How the codes mapped onto the overarching themes are shown in Table 2.

Table 2: Characteristics of the participants

Characteristics	Number of participants, n
Gender	
Female	15
Male	5
Age	
25-34	4
35-44	8
45+	7
Ethnicity	
White	13
Asian	5
Black	1
Mixed	1
Specialty and clinical role	
Dermatology	5
Consultant/Trainee/Nurse	3*/1/1
General practice	6

GP/Trainee/Advanced Nurse Practitioner	4** (one locum)/1/1
Emergency care consultants	2
Acute medicine consultants	2
Infectious disease consultant	1***
Lymphoedema nurse	1
General Surgery trainee	1****
Tissue Viability nurse	1
District nurse	1
*One subspecialises in lymphoedema ** One subspecialises in dermatology *** Also works in acute medicine **** Also worked as an emergency care locum	
Years of clinical experience	
<10	6
11-20	9
20+	5
Number of times the HCP diagnosed lower limb cellulitis	
11-50	6 (30)
50+	14 (70)
Time since the HCP last made a diagnosis of cellulitis	
<1 month	16
1-6 months	3
6+ months	1

185

186 ## The patient presentation

187 ### *The continuum of clinical features*

The presentation of lower limb cellulitis changes as the episode runs its course. This will be influenced by when patients seek clinical review and means that different specialties see clinical features at varying stages of cellulitis.

In general practice, the typical presentation includes older people with co-morbidities such as heart failure and poor mobility (Participant (P) 11, GP trainee); concerns of possible cellulitis cases are often raised by district nursing colleagues. Emergency care and acute services often see people who present with features of systemic compromise (P4, acute medicine consultant). Both infectious disease and general surgery services often see intravenous drug users who are at risk of deeper infection (P2, infectious disease consultant; P16, surgical trainee).

In dermatology services, presentations were seen later in the episode '*usually the patient is already admitted ….. [the referring team] have tried [multiple antibiotics], but nothing is happening, "please can you come and tell us what is going on?*' (P9, dermatology consultant). This partial treatment and response can make the diagnosis challenging as the initial typical features of cellulitis may now vary '*there are varying ranges of erythema, from a little bit of light pinkness to rip roaring hot red, tender, well demarcated, unilateral; the classic sort of textbook stuff* (P18, dermatology registrar). However, seeing patients later in the journey allowed dermatologists to appreciate the progression of clinical features '*I learnt to appreciate much more that [cellulitis] is*

coming up, it is happening and that it is fading away….you're looking at this leg that has generally sort of this post inflammatory pinkness, but if you look at patient photos it was much more kind of classical earlier on so it is kind of a reassuring the medical team saying yes this is probably resolving cellulitis at this point ' (P18). Importantly for dermatologists, other more serious pathologies such as a deep vein thrombosis (DVT) had often been ruled out, '*virtually every patient that I see...they have had their d-dimer and their duplex done so [DVT] is usually a diagnosis that has been excluded* (P20, dermatology consultant).

Factors that increased the likelihood of cellulitis were: features of systemic upset including fever, malaise, rigors (P12, GP locum); co-existing injury or infection such as tinea, superficial ulceration, previous history of cellulitis, previous history of dermatological conditions such as eczema, diabetes, immunosuppressive medications such as steroids (P19, emergency care consultant) and those with no fixed abode with social and health risks (P9).

Who should diagnose cellulitis?

When asked about the most ideal HCP to diagnose cellulitis, participants often felt their own specialty were, but learning from experience was key '*I would say it is just experience [helping diagnosis], a lot of the juniors that come into A&E have not seen that many cellulitis*' (P19).

Many nurses felt that they were seeing cellulitis more often than doctors (P11) and this view was supported by doctors *'[community nurses] probably see [cellulitis] most and are the best placed for it to be diagnosed….cellulitis that walks in and walks out doesn't really need to be in A&E'* (P19).

One dermatologist explained how being '*more aware of the differentials*' made them more likely to accurately diagnose cellulitis, but that ideally cellulitis should be managed in the community as '*it's a really common condition*' (P15, dermatology consultant).

Cases of uncertainty

When discussing cases of uncertainty, where cellulitis was the eventual diagnosis, one dermatologist described a case of bilateral cellulitis '*you are always told it is never bilateral cellulitis, but it was and they were incredibly unwell*' (P15). Trauma related skin changes was frequently an initial mis-diagnosis in the emergency department '*one of my nurse practitioners had seen ankle swelling… she thought it was just a sprain but then next day presented [again] and I saw him and it looked more like cellulitis… on close examination I could see a couple of scratches…so that was maybe the source of cellulitis*' (P8, emergency care consultant).

When discussing cases of uncertainty, where cellulitis was the initial suspected diagnosis, one GP described a case of venous eczema which was managed with repeated antibiotics '*generally*

anything that is red and hot and on the legs is treated with antibiotics' (P1, GP). Chronic rashes were frequently seen by dermatology '*There are too many chronic rashes that get referred as cellulitis*' (P18) and infectious disease discussed lymphoma cases initially referred as cellulitis '*We did see [patients] coming in with "oh this must be a resistant cellulitis", have got a swollen limb that might be a little bit red and it turns out to be some horrible form of lymphoma, you maybe get one or two of them every year*' (P2).

A frequent diagnosis of uncertainty for primary and emergency care was DVT, as the clinical features of cellulitis can overlap '*one thing that is always a problem in leg swelling…it is difficult to ascertain between DVT and cellulitis*' (P8). Common differential diagnoses discussed by participants, which they observe in their clinical practice, with discriminating features from cellulitis are shown in Table 3. Of these, dermatologists mentioned skin specific differentials, GPs included non-skin specific differentials, whilst acute physicians and surgeons mentioned more acute pathologies.

Table 3: Differential diagnoses of lower limb cellulitis discussed by participants

Differential diagnoses	Key differentiating factors from cellulitis

Chronic heart failure causing oedema	Chronic, bilateral, lack of mobility, breathless, cardiac history (P1,14)
Venous eczema	Usually chronic with hemosiderin scaling, itching, crusting, likely bilateral, possibly eczema elsewhere on body, less well defined, (P3,15)
Thrombophlebitis	Tender, localised, hard, lumpy rash around an often thickened vein (P3,5,12)
Erythema nodosum	Multiple, discrete swellings (P13)
Deep vein thrombosis	Pain is usually deep in calf rather than superficial, less sharply demarcated and less intense erythema, diffuse swelling of limb, can be young, can be intravenous drug users, high DVT wells score, fewer systemic features (P2,12, 13)
Lymphoedema	Chronic, bilateral, usually less painful, thickened warty skin in the long-term, normal inflammatory markers (P9,18)
Allergic reaction to insect bites	Central puncture mark, itch, when acute, developing lichenified erythema when chronic (P2)
Lipodermatosclerosis	Often bilateral, systemically well, tight non tender skin with inverted champagne bottle appearance (P4, P20)
Necrotising fasciitis	Crepitus, rapidly spreading, septic, very tender (P5, P16)

Wound infection	Local to the wound, covers small area, yellow exudate, strong odour (P10, P16)
Baker's cyst	Unilateral popliteal swelling, suddenly more tender on rupture (P15)

Challenges leading to diagnostic uncertainty

A subjective diagnosis

There were multiple challenges with diagnosis identified. A GP explained how there is no specific test that can aid diagnosis, thus subjective assessment can lead to different diagnoses '*I think the fact that there is no specific diagnostic test and it literally goes on well how does this look clinically? And two different people can look at something and come up with two different answers, so depending on where they have practiced, how they have practiced and how long*' (P1).

Community challenges

In the community, additional challenges for GPs were not being familiar with the patient's background history, when seeing a patient for the first time, or taking over care part way through the patient journey (P11). Working as a locum doctor with a lack of follow up often led to treatment

when unsure '*you've not met the patient before and sometimes you're not going to be able to follow them up so you probably are more likely to give antibiotics*' (P12). Limited resources to see patients, such as not being able to conduct an urgent home visit, also influenced diagnosis and subsequent management '*if you know the patient and you know that they have recurrent cellulitis and someone had seen it like a district nurse and it is Friday afternoon and you can't get out and so you know in that situation yes you would make a judgement call* (P1).

The role of 'defensive' medicine

HCPs in the community, emergency care and surgery were particularly wary of missing a more serious diagnosis, which needed to be ruled out first, such as DVT and necrotising fasciitis (NF): '*I think you would want to rule out DVT first because if you miss that then that is… a problem*' (P1, P16). Many HCPs also mentioned '*sepsis*' when discussing clinical features and diagnosis '*we're so much more aware of things like sepsis for example…that I think we are more geared up to looking at any kind of signs of infection*' (P10, district nurse). This may be leading to an over diagnosis of cellulitis due to concerns of medico legal complaints '*We're all risk adverse aren't we? We would rather make sure we weren't sued because we had missed someone with an infection*' (P2).

One consultant felt that not knowing the mimics made the diagnosis more difficult for junior colleagues '*people don't realise there are mimics out there, they just go red leg equals cellulitis*' (P2). A trainee felt seeing less cellulitis cases during their training compared to their senior colleagues historically and '*not getting as much exposure*' (P18) hindered accurate diagnosis.

Patient specific factors

People with pigmented skin, lymphoedema (P4) and the group who '*come in none specifically unwell …but there is nothing else to go on, [when] examining the patient*' (P5, acute medicine consultant) were particularly difficult to diagnose in the acute setting. Another diagnostic challenge was when a patient presents with chronic skin changes or a recent episode of cellulitis with continuing signs *'people with chronic red [legs], their legs are red most of the time, so it is varying degrees of red and the skin takes so long to settle so they could have had cellulitis four weeks ago and it is still red'* (P17, advanced nurse practitioner).

Strategies to improve diagnosis

Using time as a guide

In cases where the HCP was not sure of the diagnosis, different strategies were employed. Using time to allow further clinical features to develop, with appropriate safety netting was a commonly used approach '*all you can really do is reassure the patient and say…I don't see any clear*

evidence of cellulitis but we will keep an eye on it.... you give safety net advice to the patients' (P18). This is easier when follow-up appointments may be available in the community, but was also done in the acute setting '*So if they were well.. then I would bring them back to clinic the next day or two*' (P4). But follow-up in secondary care is difficult, often not done (P8) and can be a missed opportunity to learn from incorrect diagnoses previously (P2).

Trial of treatment

Some HCPs will start antibiotics for a suspected cellulitis and review the response to help provide the diagnosis retrospectively '*cellulitis…was the easiest thing to try and treat so I think that definitely pushed [me] to try some antibiotics and see if this is an infection*' (P11). However, the concerns with this were '*antibiotic resistance and side effects…especially in older groups*' (P3, GP).

Biochemical investigations

In primary care, blood tests and cultures were rarely done to diagnose cellulitis '*if I am thinking about doing blood tests…it is unlikely that I am going to continue managing them in the community*' (P11). Blood cultures were requested by the infectious disease physician if it was an atypical infection '*toxic bug and their skin is shearing off*' (P2), but a challenge is '*in the majority of patients we don't isolate [organisms]* (P20). Swabs were done for discharging wound

infections, mainly by district nurses '*routinely it is quite the norm*' (P14, dermatology nurse) or prior to discussion with microbiology (P18).

An emergency physician and surgical trainee explained how blood tests and imaging such as x-rays are important to check for osteomyelitis (P16). The blood tests commonly requested by secondary care HCPs were white cell count (WCC) and C-reactive protein (CRP) for infection with one dermatologist stating how changes in blood test results were important when taking referrals for suspected cellulitis '*[with cellulitis]….you expect a) it is unilateral, b) you want some inflammatory markers which are raised, at least a reasonable WCC and CRP and if it is normal it is not going to be cellulitis'* (P9). However, one challenge with interpreting blood tests was in the group partially treated with antibiotics, who have improving blood tests but limited clinical response, for which one acute physician added '*I would never not diagnose somebody [with cellulitis] just because their inflammatory markers are normal*' (P5).

A biomarker (P20) or point of care test (P12) for cellulitis were suggested as investigations to aid diagnosis.

Seeking advice

Another approach during uncertainty is to discuss with colleagues. In the community the nurse may ask the GP to review and vice versa. In hospital, specialists in infectious disease, dermatology, microbiology and general/plastic surgeons are most often contacted for review.

The use of technology, specifically photography is a '*good way to see the progression*' of cellulitis and in discussion with colleagues '*we took a photograph of it and…showed it to [the GP] and got some antibiotics*' (P10).

Further education

Many HCPs mentioned teaching sessions to improve diagnosis as '*you very quickly just get entrenched in your style of practice, your preferences for diagnoses and it is often good to refresh*' (P11), both at the undergraduate and postgraduate level as '*I only did two weeks as a medical student and given in general practice something like what is it 20% of consultations have a skin element in them?* (P13, GP out of hours). Real life clinical cases was felt to be important for teaching '*Sometimes unless you are seeing it, it is all very well seeing pictures but the pictures aren't that helpful sometimes, it is how it feels sometimes that makes a difference and actually seeing it in the flesh is very different to seeing even a good quality picture [which] is not the same*' (P13).

A key area of education amongst HCPs was being aware of differential diagnoses for the first point of access services, '*it is not something people will have put a lot of thought into, the differentials, and I think the focus needs to be on teaching the frontline staff*' (P15). A trainee who worked in a specialist cellulitis clinic found that seeing many cases helped '*pattern recognition and [seeing] variation in progression of the rash*', thereby appreciating the '*life of rashes*' (P18).

The need for an objective diagnostic aid

A diagnostic algorithm

Many participants mentioned developing a diagnostic algorithm, similar to the Wells score for DVT '*I think when there is a sort of a criteria it can help to confirm your thinking because a lot of the time it just feels more slightly softer in that it is based on your eye, your individual experience but I think it can be helpful to have those objective measures..if it was accepted and validated as a reasonable measure of cellulitis, I think I would actually use that*' (P11). In the community this would '*not require any more special kit or testing or time*' (P10). This may also help GPs make a validated clinical decision when colleagues such as district nurses are suspecting cellulitis and the patient cannot be seen quickly (P12). Nurses often use checklists and this '*just gives you something to think about like oh… I hadn't thought about the heat*' (P14). One dermatologist

suggested that a diagnostic checklist should be more of an educational tool to help rule out other differential diagnoses '*for a diagnostic checklist you almost want it to be provided as an education tool with photographs and descriptions…. so that people can put these differential diagnoses into their head* (P15).

One trainee felt that the indices of a checklist would have to reflect how cellulitis changes through the course of the episode '*you would have to develop a criteria that can pick up the…beginning, it is in the middle and it is resolving at the end* (P18). Other challenges with developing an algorithm were the number of alternative diagnoses with features that often overlapped with cellulitis and vague initial features '*Because there is such a wide differential…how would you exclude all of those and also it can be quite nonspecific sometimes in the early stages*' (P12). Another concern regarding an algorithm was missing outliers '*sometimes the trouble with guidelines, algorithms…. you could probably cover 95% but does it mean that actually the atypical 5% then [do not] get diagnosed?* (P20).

Indices for an algorithm

The key clinical features HCPs suggested to include in a diagnostic algorithm for lower limb cellulitis were: unilateral, pain, erythema, warmth of limb, pyrexia, swelling, acute onset, trauma to the limb, break in the skin, single area affected (P13), clear demarcation (P3), exudate, flu like

malaise, tracking rash (P17), shiny, tenser skin (P8), previous cellulitis, co-existing immunosuppression, co-existing skin conditions, clinical observations for sepsis (P19), negative Wells score (P17) and patient concern. One participant also suggested bullae to be included (P18). No HCP suggested blood tests were a priority in the algorithm, but could be included in a modified algorithm in secondary care, similar to the CURB-65 used for pneumonia severity (P11).

Discussion

Summary

This study found that the presentation of lower limb cellulitis changes as the episode progresses, leading to variation in the clinical features, seen in different clinical settings. This may be reflected in the range of typical differential diagnoses that specialities discussed.

Clinical experience was described as an important factor in making a more accurate diagnosis. However, the clinical reasoning behind a diagnosis were contradictory between some HCPs, such as the use of blood tests to indicate an infection or whether cellulitis can be 'bilateral'.

A core group of clinical features to diagnose cellulitis were suggested. But the challenge is that these features can overlap with other pathologies, irrespective of how likely these are. More serious pathologies then need to be ruled out first, both for the safety of the patient and to avoid medico-legal consequences.

Suggestions to improve the accuracy of diagnoses included developing a diagnostic algorithm which could objectively help HCPs with different levels of experience. The challenge with a diagnostic algorithm is that it would need to incorporate the various stages of a cellulitis episode and therefore various versions of an algorithm might be required.

Importantly, having a greater understanding of the alternative diagnoses is required, especially when the features are vague, atypical or not responding to antibiotic treatment. Educating both doctors and nurses, using real life clinical scenarios and a focus on differential diagnoses, was also discussed and may be an initial feasible approach to improve diagnostic accuracy.

Strengths and limitations

A key strength of this study is the methodology used, with two independent coders following a standardized codebook. Participants were included nationally around the UK, across various specialities that commonly diagnose cellulitis, with both nurses and doctors of varying clinical experience.

The major limitation of this study was that some participants were unable to fully describe their clinical rationale behind diagnostic decisions during the interview. This may be because they have developed an intuitive, pattern-recognition, approach in decision-making with experience.

Furthermore, as the interviewer was a fellow clinician, interviewees may not have fully shared the details of cases that were misdiagnosed or where diagnoses were delayed due to social desirability bias or fear of litigation.

Comparison with existing literature

To our knowledge, this is the first interview study undertaken with health care professionals, discussing their experiences of cellulitis diagnosis. Our findings on the clinical features of cellulitis,

differential diagnoses and also the need to be aware of mimics have been described in previous review articles [7]. A previous scoping review also described cases of misdiagnosis and emerging approaches to improve diagnoses [5], which were echoed in this study.

Implications for research and practice

This study has highlighted that HCPs need to be aware that cellulitis can present with different features at various stages of the acute episode and need to consider the cellulitis mimics. With a current shift in health care resulting in trained nurses now managing more acute presentations, upskilling nurses in cellulitis could be part of the solution.

Many HCPs felt confident in making an accurate diagnosis, often guided by experience and intuition, but found it difficult to verbalise the key distinguishing features. This makes it difficult for the clinical experience to be shared amongst other colleagues, especially less experienced or junior HCPs. To overcome this, further qualitative research is required to identify the clinical reasoning behind the expert process of making a diagnosis, perhaps using clinical cases and pictures. This will form the basis of the proposed solution of focused education and clinical features to be included in a diagnostic aid.

Some indices for a diagnostic algorithm have been identified in this study, as well as key distinguishing features from differential diagnosis, but these need validating with larger studies and an expert consensus setting exercise.

Conclusion

This interview study has shown that cellulitis is a complex diagnosis. Not only does the core features overlap with other diagnoses, the presentation of cellulitis changes as the episode progresses. Although cellulitis is a common diagnosis to make, and whilst further research in developing diagnostic aids needs to be undertaken, simply being aware of the cellulitis mimics may help improve diagnostic accuracy.

Acknowledgements

We would like to thank the participants who were interviewed and the professional transcriber Claire Poxon. We also want to thank the Royal College of General Practitioners for supporting this study. The views expressed in this paper are those of the authors and not necessarily those of the National Health Service, the National Institute for Health Research or the Department of Health.

Competing interest

None declared

Author contributions

M Patel was involved with the design of the study, collection and analysis of data, drafting the manuscript and final approval of the manuscript.

S I Lee was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

NJ Levell was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

P Smart was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

J Kai was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

KS Thomas was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

P Leighton was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

References

1 Lazzarini L, Conti E, Tositti G, et al. Erysipelas and cellulitis: clinical and microbiological spectrum in an Italian tertiary care hospital. *J Infect* 2005; **51**(5):383-9.

2 Weng QY, Raff AB, Cohen JM, et al. Costs and Consequences Associated With Misdiagnosed Lower Extremity Cellulitis. *JAMA Dermatol* 2017; **153**(2):141–146.

3 Patel M, Lee SI, Akyea RK, et al. A systematic review showing the lack of diagnostic criteria and tools developed for lower limb cellulitis. In print: *Br J Dermatol* 2019.

4 Thomas KS, Brindle R, Chalmers JR, et al. Identifying priority areas for research into the diagnosis, treatment and prevention of cellulitis (erysipelas): results of a James Lind Alliance Priority Setting Partnership. *Br J Dermatol* 2017; **177**:541-543.

5 Patel M, Lee SI, Thomas KS, Kai J. The red leg dilemma: a scoping review of the challenges of diagnosing lower-limb cellulitis. *Br J Dermatol* 2019; **180**: 993-1000.

6 Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol* 2006; **3**: 77-101.

7 Bailey E, Kroshinsky D. Cellulitis: diagnosis and management. *Dermatol Ther* 2011; **24**(2):229-239.

Figure 1: Standardised codebook used by two independent coders

Supplementary Materials

Figure 1: Topic guide used to structure the interview

Codes used

- Trial of treatment guides diagnosis
- Discussing diagnosis with colleagues
- Time and safety netting approach
- Patients who self-diagnose and treat
- Approach when HCPs do not agree with patient self-diagnosis
- Patients involved with diagnosis with the HCP
- Typical cellulitis presentations
- Clinical features of cellulitis
- Factors that decrease the likelihood of cellulitis diagnosis
- Factors that increase the likelihood of cellulitis diagnosis
- Investigations to aid diagnosis
- Missed/delayed diagnosis of cellulitis (final diagnosis)
- Missed/delayed diagnosis of cellulitis (initial diagnosis)
- Patient finds it difficult to accept it is not cellulitis
- Reasons why cellulitis diagnosis is challenging
- Suggestions on what may improve diagnosis
- Views on diagnostic aids for HCP
- Views on diagnostic aids for patients
- Views on how well HCP make diagnosis
- Experience guides diagnosis
- Seeing patients part way through assessment and management
- Differential diagnoses
- Sepsis as a concern
- Medico legal issues as a factor
- Follow up of patients
- Most suitable HCP to diagnose cellulitis
- Fear of missing more serious differentials
- Clinical features to include in diagnostic algorithm
- Other factors influencing diagnosis

If the participant has a recent case of cellulitis that they can discuss:

Can you tell me about a case of cellulitis that you diagnosed?

Prompts:

- What thoughts go through your head when you are considering a diagnosis of cellulitis?
- What symptoms do you ask about? Local? General?
- What signs do you look for? Local? General?
- Are there any specific signs/symptoms you rely on to help?
- Did you do any tests?
- Did you seek advice from anyone else?
- Were you concerned that this may not be cellulitis?
- If you were concerned, why?
- Was there anything challenging about this case?
- How did you address these challenges?
- How confident were you that this was cellulitis on a 1-10 scale when you first saw the patient?
- Did the patient discuss any self-diagnoses?
- Did any external factors such as time influence your decision?
- Did the patient come back to see you again?
- Would you change your approach if the same case presented again?
- Is this a typical case you see?
- What are the main differential diagnoses you see?

Repeat the above for a maximum two cases that the participants may have for the interview (repeat twice only if the participant has no delayed/incorrect cases below).

If the participant has a case where the diagnosis was delayed or incorrect (can be initially either seen by same health care professional or a colleague, but preferably the same person)

Prompts:

- Did you see the patient on initial presentation or was it a colleague?
- If it was another colleague, what specialty did they work in?
- What symptoms did they present with?
- What signs did they have?
- What was the initial diagnosis? And why?
- Were any tests done?
- Did any external factors influence the decision for the initial diagnosis?
- When did they see you or another colleague again?
- If it was another colleague, what specialty did they work in?
- Did anything change with the signs/symptoms?
- What happened next?
- Do you know what the final diagnosis was?
- What were the reasons for the delay in the diagnosis?
- Why was it difficult to make an accurate diagnosis on first consultation?

We want to establish if it is possible to determine a core group of features that can be used to help diagnose lower limb cellulitis

Prompts:

- What symptoms are you asking about?

- Of these symptoms, which do you think are more suggestive of cellulitis?
- Are there any symptoms that make cellulitis less likely?
- Are there other features in the history which make cellulitis more/less likely? (prompt – other conditions, previous history, drugs, family history)
- What signs are you looking for?
- Of these signs, which do you think are more suggestive of cellulitis?
- Would you request any tests if it was available to you on the same day?
- If so what tests would these be?
- Are there any signs in a 'red leg' that would make cellulitis less likely as the diagnosis?
- Are there any signs in a red leg which would make cellulitis more likely as the diagnosis?
- How has your approach to diagnosing cellulitis changed after managing previous cases?
- If the patient has had previous cellulitis, does this influence your diagnosis?
- From your experience, what differential diagnoses do you think about?
- How do you distinguish cellulitis from these differential diagnoses?
- Specifically, how do you differentiate cellulitis from lymphoedema?
- Specifically, how do you differentiate cellulitis from venous eczema?
- Specifically, how do you differentiate cellulitis from infected venous eczema?
- Specifically, how do you differentiate cellulitis from lymphodermatosclerosis?
- Do you feel that a list of key diagnostic features of cellulitis would help when assessing patients?

We want your views on some aspects of diagnosis that patients with recurrent cellulitis and lymphoedema have discussed

- Patients felt that they were confident in making a self-diagnosis of cellulitis and valued greater trust in self-management at home with treatment. What are your thoughts on patients self-diagnosing?
- Would a photograph with a proforma taken and filled in by the patient and sent to you be helpful in managing patients with recurrent cellulitis?
- In the instance where you may not agree with the patients self-diagnosis of cellulitis, how would you manage the diagnosis?
- Do you feel that any further training or resources should be set up to help improve our diagnosis of cellulitis? For example as specialist cellulitis clinic to refer patients to?
- What are your thoughts on health care professionals having a guide such as checklist to help diagnosis?
- Do you think patients should have this checklist? If so why or why not?

Centre of Evidence Based Dermatology,
The University of Nottingham,
King's Meadow Campus,
Lenton Lane,
Nottingham,
NG7 2NR

The Editor,
BMJ Open

2nd October 2019

Dear Editor,

We would be grateful if you would consider the enclosed article for publication in your journal.

Helping health care professionals (HCP) to improve diagnosis has been determined as key for future cellulitis research. There is a lack of knowledge about HCPs experiences and challenges in diagnosing suspected lower limb cellulitis.

We sought to explore the experiences and challenges in diagnosing suspected lower limb cellulitis through a national interview study involving doctors and nurses in various specialties including dermatology, primary care and acute services.

Four key themes emerged. The presentation of lower limb cellulitis changes as the episode runs its course. Therefore, different specialties see clinical features at varying stages of cellulitis. Clinical experience is essential to being confident in making a diagnosis, but even amongst experienced HCPs, there were differences in the clinical rationale of diagnosis. A group of core clinical features were suggested, many of which overlapped with alternative diagnoses. This emphasises how the diagnosis is challenging, with objective aids and a greater understanding of the mimics of cellulitis required.

We conclude that cellulitis is a complex diagnosis and has a widely variable clinical presentation at different stages. Although cellulitis is a common diagnosis to make, HCPs need to be mindful of alternative diagnoses.

We hope this article will stimulate further research on the diagnosis of lower limb cellulitis. Cellulitis is of particular interest to many health care professionals in various specialties and therefore we feel this article should target a journal that reaches a wide audience.

All authors declare no conflicts of interest and have read and approved this version. The requirements for authorship have been met.

Dr Mitesh Patel, the primary author for this paper, can be contacted at
Email address: mpatel59@doctors.org.uk
Tel: 0115 823 1048

If you have any questions concerning this paper please do not hesitate to contact me.

Yours sincerely,

Dr Mitesh Patel MBChB, BSc, PGCert

Standards for Reporting Qualitative Research (SRQR)*

http://www.equator-network.org/reporting-guidelines/srqr/

	Page/line no(s).
Title and abstract	
Title - Concise description of the nature and topic of the study Identifying the study as qualitative or indicating the approach (e.g., ethnography, grounded theory) or data collection methods (e.g., interview, focus group) is recommended	Page 1/line 1-2
Abstract - Summary of key elements of the study using the abstract format of the intended publication; typically includes background, purpose, methods, results, and conclusions	Page 2/lines 43-67
Introduction	
Problem formulation - Description and significance of the problem/phenomenon studied; review of relevant theory and empirical work; problem statement	Page 4/ lines 91-102
Purpose or research question - Purpose of the study and specific objectives or questions	Page 4/lines 101-102
Methods	
Qualitative approach and research paradigm - Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., postpositivist, constructivist/ interpretivist) is also recommended; rationale**	Page 7/lines 157-158
Researcher characteristics and reflexivity - Researchers' characteristics that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, and/or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, and/or transferability	Page 6/ lines 137-140
Context - Setting/site and salient contextual factors; rationale**	Page 6/lines 141-144
Sampling strategy - How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling saturation); rationale**	Pages 5-6/ lines 123-136
Ethical issues pertaining to human subjects - Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues	Page 5/ lines 112-116
Data collection methods - Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources/methods, and modification of procedures in response to evolving study findings; rationale**	Page 6/ lines 145-151

Data collection instruments and technologies - Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study	Page 6/ lines 145-151
Units of study - Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)	In the results, Page 8/lines 175-176 and Table 1
Data processing - Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and anonymization/de-identification of excerpts	Page 6/ lines 152-154
Data analysis - Process by which inferences, themes, etc., were identified and developed, including the researchers involved in data analysis; usually references a specific paradigm or approach; rationale**	Page 7/lines 156-162
Techniques to enhance trustworthiness - Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationale**	Page 7/ lines 159-162

Results/findings

Synthesis and interpretation - Main findings (e.g., interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory	Pages 8-19/ lines 174-383
Links to empirical data - Evidence (e.g., quotes, field notes, text excerpts, photographs) to substantiate analytic findings	Pages 8-19/ lines 174-383

Discussion

Integration with prior work, implications, transferability, and contribution(s) to the field - Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application/generalizability; identification of unique contribution(s) to scholarship in a discipline or field	Page 20/lines 389-407, Page 21-22/ Lines 421-441
Limitations - Trustworthiness and limitations of findings	Page 21/ lines 410-420

Other

Conflicts of interest - Potential sources of influence or perceived influence on study conduct and conclusions; how these were managed	Page 23/line 453-454
Funding – Sources of funding and other support; role of funders in data collection, interpretation, and reporting	Page 1/ lines 22-23

*The authors created the SRQR by searching the literature to identify guidelines, reporting standards, and critical appraisal criteria for qualitative research; reviewing the reference lists of retrieved sources; and contacting experts to gain feedback. The SRQR aims to improve the transparency of all aspects of qualitative research by providing clear standards for reporting qualitative research.

**The rationale should briefly discuss the justification for choosing that theory, approach, method, or technique rather than other options available, the assumptions and limitations implicit in those choices, and how those choices influence study conclusions and transferability. As appropriate, the rationale for several items might be discussed together.

Reference:

O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. **Standards for reporting qualitative research: a synthesis of recommendations.** *Academic Medicine*, Vol. 89, No. 9 / Sept 2014
DOI: 10.1097/ACM.0000000000000388

A qualitative study to determine the health care professionals' experience of the diagnosis of lower limb cellulitis

Final Version 1.0
31.10.2018

Short title: Diagnosing lower limb cellulitis

IRAS Project ID: 254088

Study Sponsor: University of Nottingham

Sponsor reference: 18072

Funding Source: Funding from the RCGP Practitioners allowance will be sought, providing a maximum of £2000. The application form requires the sponsor to agree to act as a research sponsor and so will be submitted after this ethics application has been submitted.

STUDY PERSONNEL AND CONTACT DETAILS

Sponsor:
Contact name

University of Nottingham
Ms Angela Shone
Research and Innovation
University of Nottingham
East Atrium
Jubilee Conference Centre
Triumph Road
Nottingham
NG8 1DH

Chief investigator:

Professor Kim S Thomas
UoN job title: Professor and Co-Director
Centre of Evidence Based Dermatology
University of Nottingham
Nottingham
NG7 2NR
Phone: 0115 846 8630
Email: mszkst@exmail.nottingham.ac.uk

Co-investigators:

Dr Mitesh Patel
UoN job title:
Academic Clinical Fellow GP ST4
The Tower, University Park
University of Nottingham
Nottingham
NG7 2RD
Phone: 0115 74 86834
Email: msamp9@exmail.nottingham.ac.uk

Professor Joe Kai
UoN job title: Professor and Head of Primary Care
The Tower, University Park
University of Nottingham
Nottingham
NG7 2RD
Phone: 0115 846 67845
Email: mczjk@exmail.nottingham.ac.uk

Professor Paul Leighton
UoN job title:
Associate Professor of Applied Health Services Research
Centre of Evidence Based Dermatology
University of Nottingham
Nottingham
NG7 2NR
Phone: 0115 84 68629

Email: mczpal1@exmail.nottingham.ac.uk

Dr Peter Smart
Patient representative

Title	A qualitative study to determine health care professionals' experience of the diagnosis of lower limb cellulitis
Short title	Diagnosing lower limb cellulitis
Chief Investigator	Professor Kim S Thomas
Objectives	• Describe the key clinical features which inform the diagnosis of lower limb cellulitis • Explore the difficulties in making a diagnosis of lower limb cellulitis
Study Configuration	Semi-structured interviews with health care professionals regarding lower limb cellulitis
Setting	Primary and secondary care
Number of participants	Approximately 20
Eligibility criteria	Age >18 years All ethnicities Be a qualified health care professional

Centre of Evidence Based Dermatology
University of Nottingham
Nottingham
NG7 2NR
Phone: N/A
Email: smartpeterdr@btinternet.com

Professor Nick J Levell
Consultant Dermatologist
Norfolk and Norwich University Hospital
Norfolk
NR4 7UY
Phone: 01603 288255
Email: nick.levell@nnuh.nhs.uk

Study Coordinating Centre:

Centre of Evidence Based Dermatology
King's Meadow Campus
University of Nottingham
Nottingham
NG7 2NR

	Have managed a clinical case of suspected cellulitis of the lower limb in the UK A minimum of two years clinical experience as a health care professional, which includes managing lower limb cellulitis Able to give informed consent Speak English language
Description of interventions	One face-to-face or telephone interview lasting 45-60 minutes
Duration of study	February 2019- July 2019
Methods of analysis	Framework thematic analysis

SYNOPSIS

ABBREVIATIONS

CI	Chief Investigator overall
CRF	Case Report Form
GCP	Good Clinical Practice
NHS	National Health Service
PI	Principal Investigator at a local centre
PIS	Participant Information Sheet
REC	Research Ethics Committee
R&D	Research and Development department
UoN	University of Nottingham
CEBD	Centre of Evidence Based Dermatology
RCGP	Royal College of General Practitioners

TABLE OF CONTENTS

STUDY BACKGROUND INFORMATION AND RATIONALE

Cellulitis is an acute bacterial inflammation of the dermis and associated subcutaneous tissue, with 60% of cases affecting the lower limb [1]. The diagnosis of cellulitis can be challenging, with 31% of presentations of suspected lower limb cellulitis in the emergency department found to be other diagnoses [2]. Routine biochemical and haematology blood tests and blood cultures are not specific for cellulitis [3]. This results in avoidable hospital admissions and unnecessary antibiotic prescribing [4]. Definitive diagnostic criteria would also improve the validity of clinical research on cellulitis [5], but there are no agreed diagnostic criteria for cellulitis.

Cellulitis cases commonly present to primary care services or the emergency department [6]. A recent cellulitis research priority setting partnership (PSP), ranked questions on 'diagnostic criteria' and identifying early signs and symptoms as important for future cellulitis research [7].

A scoping review we conducted, showed 44 different pathologies misdiagnosed as cellulitis on initial presentation (accepted with changes, British Journal of Dermatology).

A systematic review we carried out, showed that there are no robustly developed and validated diagnostic tools or criteria for lower limb cellulitis (in submission, British Journal of Dermatology). Despite eight potential tools having been explored so far: biochemical tests, imaging, predictive scoring and clinical features, they all provide limited clinical applicability and validity.

No previous qualitative studies have addressed the challenges in diagnosing suspected cellulitis from the health care professionals (HCP) perspective.

STUDY OBJECTIVES AND PURPOSE

PURPOSE

This study will help to establish the core features described by health care professionals (HCP) when they suspect a patient may have lower limb cellulitis. This will also help answer the question 'what are the early signs and symptoms of cellulitis that can help ensure speedy treatment': a priority from the cellulitis PSP. Furthermore, this study will also support further research on the development of diagnostic criteria for lower limb cellulitis.

OBJECTIVES

Primary

- Describe the key clinical features which inform the diagnosis of lower limb cellulitis

Secondary

- Explore the difficulties in making a diagnosis of lower limb cellulitis

STUDY DESIGN

STUDY CONFIGURATION

Face-to-face or telephone interviews, lasting approximately 45-60 minutes will be conducted with health care professionals (HCPs). A purposive sample will be selected, with HCPs

(doctors and nurses) from: general practice, dermatology, tissue viability service, lymphoedema service and either the emergency department or acute medicine.

STUDY MANAGEMENT

The study will be managed from the central coordinating centre (CEBD, University of Nottingham).

The Chief Investigator (CI) has overall responsibility for the study and shall oversee all study management.

The data custodian will be the CI.

DURATION OF THE STUDY AND PARTICIPANT INVOLVEMENT

Study Duration: Interviews will start in February 2019 and is expected to be completed by July 2019. The total duration will be six months.

Participant Duration: Each participant will take part in an interview that will last 45-60 minutes. No follow up interviews are planned. Participants will receive a summary of the study findings unless they specifically ask not to receive them. It is anticipated that up to 20 participants will be required, however more HCPs will be included if new themes emerge.

End of the Study

The end of the study will be the last interview.

SELECTION AND WITHDRAWAL OF PARTICIPANTS

Recruitment

Doctors and nurses from: general practice, dermatology, tissue viability service, lymphoedema service and either the emergency department or acute medicine, will be recruited.

Recruitment will be opportunistic in the first instance, using a sampling frame to ensure a broad representation of participants. HCPs will be emailed, briefly discussing the aims of the study, inclusion criteria and methods of the study. HCPs will be approached through:

- A pre-existing cellulitis database, co-ordinated at the Centre of Evidence Based Dermatology (CEBD), which includes general practitioners (GPs), dermatologists, emergency physicians, lymphoedema specialists and nurses. They have previously been involved with cellulitis research at the CEBD and have consented to being approached for future cellulitis studies.
- The UK Dermatology clinical trials network, co-ordinated at the CEBD, includes a broad membership of GPs, dermatologists and nurses who have consented to being approached about future dermatology studies.
- The British Association of Dermatologists, Society of Acute Medicine, Royal College of Emergency Medicine, Nottinghamshire Local Medical Committee for GPs and Primary Care Dermatology Society have agreed to advertise in their newsletters.
- Emergency department and acute medicine physicians/nurses will be recruited from Nottingham University Hospitals NHS Trust, through contacting the clinical leads of each speciality.
- GPs will be recruited by contacting seven clinical commissioning groups (CCG) leads in Nottingham.

- Dermatologists and dermatology nurses will be approached from the cellulitis clinic at Norwich and Norfolk University Hospital, with the help of NL (co-applicant) who helped set up the clinic.
- Snowball sampling where participants help recruit other participants.
- Snowball sampling where current clinical colleagues can help to recruit.
- Additional regulatory bodies such as the Royal College of Nursing and British Lymphology society.

If participation uptake is low, HCPs who have worked with members of the research team will be pragmatically approached. These HCPs will have typical demographics for which we are including in this study.

The local researcher will inform the participant of all aspects pertaining to participation in the study. All HCPs in the UK communicate in English and therefore the consent forms and information sheets will not be available printed in other languages.

It will be explained to the potential participant that entry into the study is entirely voluntary and that they can withdraw at any time but attempts will be made to avoid this occurrence. In the event of their withdrawal it will be explained that their data collected so far cannot be erased and we will use the data in the final analyses where appropriate.

Eligibility criteria

Inclusion criteria

Age >18 years
All ethnicities
Be a qualified health care professional
Have managed a clinical case of suspected cellulitis of the lower limb in the UK
A minimum of two years clinical experience as a health care professional, which includes managing lower limb cellulitis
Able to give informed consent
Speak English language

Exclusion criteria

None

Expected duration of participant participation

Study participants will be participating in the study for 45-60 minutes.

Participant Withdrawal

Participants may be withdrawn from the study at their own request. Participants will be made aware (via the information sheet and consent form) that should they withdraw the data collected to date cannot be erased and may still be used in the final analysis.

Informed consent

The Investigator will contact the participant by email before the interview to explain the details of the study and provide a Participant Information Sheet and Consent Form, ensuring that the

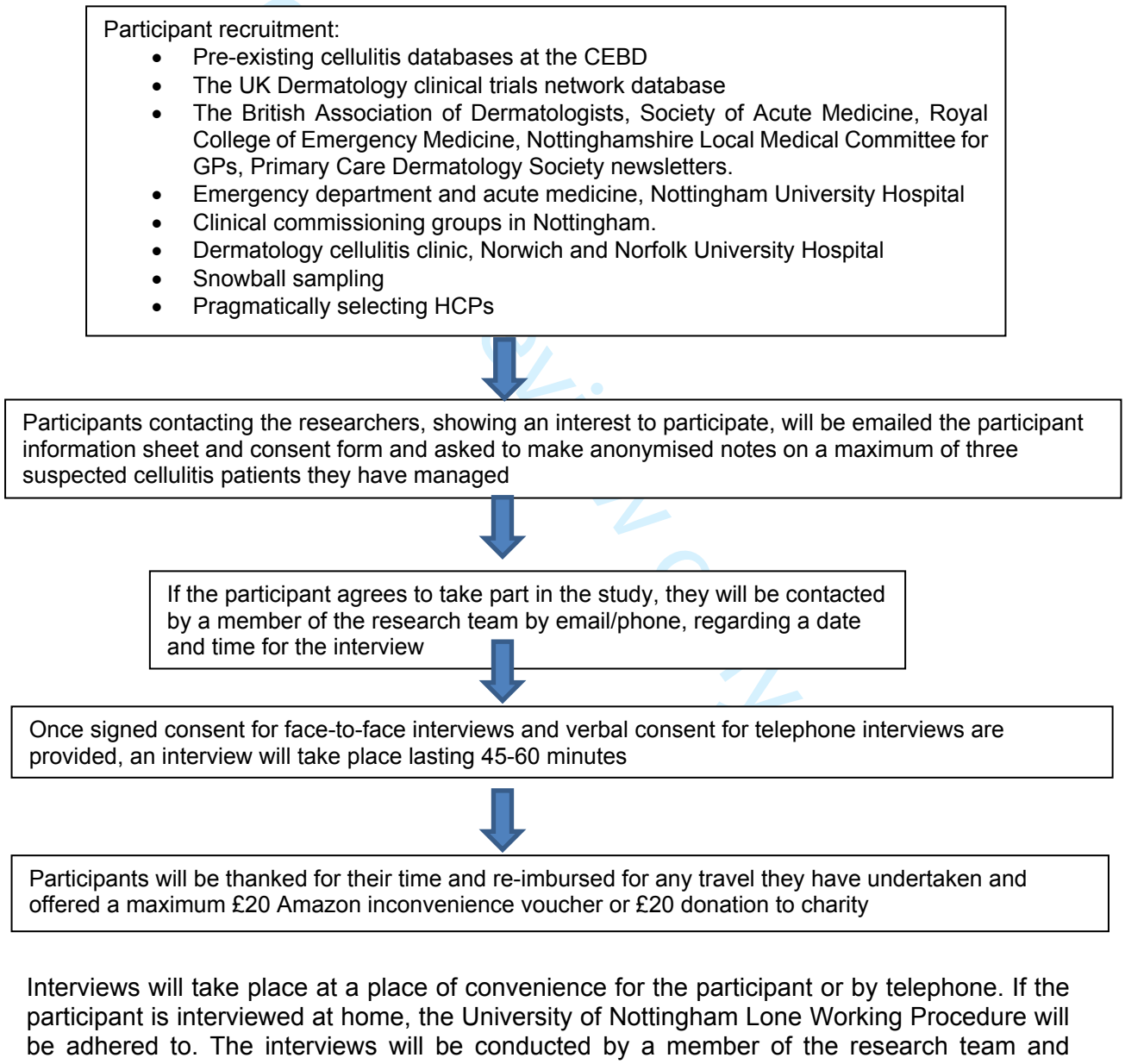
participant has sufficient time to consider participating or not. The Investigator will answer any questions that the participant has concerning study participation.

For participants giving a face-to-face interview, the Consent Form will be signed and dated by the participant before the interview. One copy of the Consent Form will be kept by the participant and one will be kept by the Investigator. On commencing the recording, the participants will be asked to confirm that they have given consent to take part and for the interview to be digitally recorded. For telephone interviews, formal, recorded verbal consent will be gained before the interview and this consent will be transcribed, as a way of documenting this.

STUDY REGIMEN

The individual steps that each participant will undertake are shown in Figure 1:

Figure 1: Study procedure



Interviews will take place at a place of convenience for the participant or by telephone. If the participant is interviewed at home, the University of Nottingham Lone Working Procedure will be adhered to. The interviews will be conducted by a member of the research team and

recorded. Transcription of data will be undertaken by a member of the research team, or a transcription service affiliated with the University of Nottingham. A set series of questions will be used for the first two interviews, but may be adapted based on the findings of these interviews.

Compliance

We do not expect any compliance issues.

Criteria for terminating the study

None.

ANALYSES

Methods

A semi-structured interview guide (see attached document) has been developed around topic themes from existing literature and in our scoping review (see Box 1), however, this is flexible to allow unanticipated themes to emerge. Participants recruited will be asked in the initial email with the participant information sheet and consent form, to make anonymised notes on a maximum of three cases of cellulitis they have managed, to discuss in the interview. They will be asked to make notes on the following topics: signs, symptoms, tests used, challenges encountered with making a diagnosis, learning points for future cases.

Box 1: Interview topic themes

Themes 1: Clinical features of suspected cellulitis

Themes 2: Experiences of diagnosis

All interviews will be audio-recorded and transcribed verbatim, with participant numbers assigned to avoid any personal identifiers.

All idiosyncratic features that add no meaning to the transcript will be removed. The cleaned transcripts will then by formatted for read-in compatibility with the data management software, password protected and stored on the secure server at the University of Nottingham.

The data transcripts will be organised using the qualitative software package QSR NVivo 12. The data will then be handled following the conventions of framework analysis [8]. A broad analytic framework based upon the topic themes and interview questions will be constructed, and subsequently refined by coding a small number of transcripts [9]. Coding will be done by one researcher (MP) and validated by an independent reviewer (JK, KT or PL). All other data will be charted to the refined framework. Once charting has been completed, thematic matrices can be interpreted and summaries of each theme / sub-theme produced (Appendix 1). Comparisons will be made between the data from different specialities.

Data storage

Copies of the audio data files will be uploaded to a secure electronic platform to allow data transfer between the study team and the transcriber. Once the transcripts have been generated, uploaded to the platform, and retrieved by the study team, the audio files will be deleted from the platform. All raw audio data files and transcripts will be encrypted, password protected and stored on a secure server at the University of Nottingham.

Sample size and justification

We approximate that 20 participants will be included as a purposive sample. This number has been chosen because it is feasible to include within the limits of study funding and time. We aim to recruit both doctors and nurses in specialties of general practice, dermatology and either the emergency department or acute medicine, as all these three specialties manage cellulitis frequently. All participants need to have at least two years of clinical experience, as this will include HCPs who have specialist registration and will likely have more clinical experience of cellulitis.

We aim to include an equal number of men and women, with varying number of years of clinical experience as their clinical experiences will change with time. With regards to the GPs and emergency care staff, we want to include both those with more specialist dermatology or infection expertise, and those without.

ADVERSE EVENTS

The occurrence of an adverse event as a result of participation within this study is not expected and no adverse event data will be collected.

ETHICAL AND REGULATORY ASPECTS

If confidential information, defined as information that may identify an individual or place, is shared during the interview, then this will be omitted from the saved copy of the transcript.

The researchers will not impart any medical judgements or opinions. However, if information is shared that may have affected patient safety, then this will be discussed with the CI and escalated as required.

ETHICS COMMITTEE AND REGULATORY APPROVALS

The study will not be initiated before the protocol, consent forms and participant information sheets have received approval / favourable opinion from the Research Ethics Committee (REC), the respective National Health Service (NHS) or other healthcare provider's Research & Development (R&D) department. Should a protocol amendment be made that requires REC approval, the changes in the protocol will not be instituted until the amendment and revised informed consent forms and participant information sheets (if appropriate) have been reviewed and received approval / favourable opinion from the REC and R&D departments. A protocol amendment intended to eliminate an apparent immediate hazard to participants may be implemented immediately providing that the REC are notified as soon as possible and an approval is requested. Minor protocol amendments only for logistical or administrative changes may be implemented immediately; and the REC will be informed.

The study will be conducted in accordance with the ethical principles that have their origin in the Declaration of Helsinki, 1996; the principles of Good Clinical Practice, and the UK Policy Framework for Health and Social Care Research 2017.

INFORMED CONSENT AND PARTICIPANT INFORMATION

The process for obtaining participant informed consent will be in accordance with the REC guidance, and Good Clinical Practice (GCP) and any other regulatory requirements that might be introduced. The investigator and the participant shall both sign and date the Consent Form, for face-to face interviews, before the person can participate in the study. Recorded verbal consent will be taken for telephone interviews before participation and the Consent Form posted after the interview to sign and return to the research team.

The participant will receive a copy of the signed and dated forms and the original will be retained in the Study records.

RECORDS

Case report form

Each participant will be assigned a participant number. There will be one case report form (CRF), keeping a record of all: participant's name, date of birth and participant study number. This form will be stored in a secure file that only the researchers can access. In line with the UoN data storage procedures, data will be stored for at least 7 years.

This CRF will be treated as confidential documents and held securely in accordance with regulations. The CRF shall be restricted to those personnel approved by the CI and recorded as such in the study records.

All paper forms shall be filled in using black ballpoint pen. Errors shall be lined out but not obliterated by using correction fluid and the correction inserted, initialled and dated.

Source documents

Source documents shall be filed at the investigator's site and may include but are not limited to, consent forms, study records, interview transcriptions and audio records. Only study staff shall have access to study documentation other than the regulatory requirements listed below.

Direct access to source data / documents

All source documents shall be made available at all times for review by the CI, Sponsor's designee and inspection by relevant regulatory authorities.

DATA PROTECTION

All study staff and investigators will endeavour to protect the rights of the study's participants to privacy and informed consent, and will adhere to the current UK General Data Protection regulation (GDPR). The CRF will only collect the minimum required information for the purposes of the study. The CRF will be held securely, in a locked room, or locked cupboard or cabinet. Access to the information will be limited to the study staff and investigators and any relevant regulatory authorities. Computer held data including the study database will be held

securely and password protected. All data will be stored on a secure dedicated web server. Access will be restricted by user identifiers and passwords (encrypted using a one way encryption method).

Electronic data will be backed up every 24 hours to both local and remote media in encrypted format.

Any medical information provided will be kept confidential.

QUALITY ASSURANCE & AUDIT

INSURANCE AND INDEMNITY

Insurance and indemnity for clinical study participants and study staff is covered within the NHS Indemnity Arrangements for clinical negligence claims in the NHS, issued under cover of HSG (96)48. There are no special compensation arrangements, but study participants may have recourse through the NHS complaints procedures.

The University of Nottingham as research Sponsor indemnifies its staff, research participants and research protocols with both public liability insurance and clinical trials insurance. These policies include provision for indemnity in the event of a successful litigious claim for proven non-negligent harm.

STUDY CONDUCT

Study conduct may be subject to systems audit for inclusion of essential documents; permissions to conduct the study; CVs of study staff and training received; local document control procedures; consent procedures and recruitment logs; adherence to procedures defined in the protocol (e.g. inclusion / exclusion criteria, timeliness of visits); accountability of study materials and equipment calibration logs.

STUDY DATA

Monitoring of study data shall include confirmation of informed consent; data storage and data transfer procedures; local quality control checks and procedures, back-up and disaster recovery of any local databases.

Study data and evidence of monitoring and systems audits will be made available for inspection by the ethics committee as required.

RECORD RETENTION AND ARCHIVING

In compliance with the University of Nottingham Code of Research Conduct and Research Ethics, the CI will maintain all records and documents regarding the conduct of the study. These will be retained for at least 7 years or for longer if required. If the responsible investigator is no longer able to maintain the study records, a second person will be nominated to take over this responsibility.

The study documents held by the CI on behalf of the Sponsor shall be finally archived at secure archive facilities at the University of Nottingham. This archive shall include all anonymised transcripts, study databases and associated meta-data encryption codes.

DISCONTINUATION OF THE STUDY BY THE SPONSOR

The Sponsor reserves the right to discontinue this study at any time for failure to meet expected enrolment goals, for safety or any other administrative reasons. The Sponsor shall take advice as appropriate in making this decision.

STATEMENT OF CONFIDENTIALITY

Individual participant medical or personal information obtained as a result of this study are considered confidential and disclosure to third parties is prohibited with the exceptions noted above.

If information is disclosed during the study that could pose a risk of harm to the participant or others, the researcher will discuss this with the CI and where appropriate report accordingly.

Data generated as a result of this study will be available for inspection on request by the participating physicians, the University of Nottingham representatives, the REC, local R&D Departments and the regulatory authorities.

PUBLICATION AND DISSEMINATION POLICY

The study results will be published in a peer reviewed academic journal and presented at conferences. All the participants will be sent the results, unless they request not to receive them. The manuscript will follow the Standards for Reporting Qualitative Research (SRQR) recommendations.

Participants will not be identifiable in the dissemination of results.

USER AND PUBLIC INVOLVEMENT

This study was developed from priorities in cellulitis research identified by patients at the cellulitis PSP. A patient with cellulitis, as a collaborator, has helped in the design of this protocol.

The results will also be discussed at the annual CEBD patient panel, with patients with various skin diseases present, including cellulitis.

STUDY FINANCES

Funding source

Funding from the RCGP Practitioners allowance will be sought, providing a maximum of £2000. The application form requires the sponsor to agree to act as a research sponsor and so will be submitted after this ethics application has been submitted.

Participant stipends and payments

Participants will be offered a £20 amazon inconvenience voucher, or a £20 donation to charity on their behalf, to participate in the study. This will ensure a gesture of gratitude, without influencing the participant response.

Travel expenses will be provided for participants to attend a face-to-face interview.

SIGNATURE PAGES

Signatories to Protocol:

Chief Investigator: (name)_____

Signature:_____

Date: _____

REFERENCES

1. Lazzarini L, Conti E, Tositti G, et al. Erysipelas and cellulitis: clinical and microbiological spectrum in an Italian tertiary care hospital. *J Infect*. 2005; 51(5):383-9.
2. Weng QY, Raff AB, Cohen JM, Gunasekera N, Okhovat JP, Vedak P, et al. Costs and Consequences Associated With Misdiagnosed Lower Extremity Cellulitis. *JAMA Dermatology*. 2017; 153(2):141–146.
3. Raff AB, Kroshinsky D. Cellulitis: A Review. *JAMA*. 2016; 316(3):325-337.
4. David CV, Chira S, Eells SJ, et al. Diagnostic accuracy in patients admitted to hospitals with cellulitis. *Dermatol Online J*. 2011 ; 17(3):1.
5. Obaitan I, Dwyer R, Lipworth AD, et al. Failure of antibiotics in cellulitis trials: a systematic review and meta-analysis. *Am J Emerg Med*. 2016; 34(8):1645-52.
6. Lee A, Levell N. Cellulitis: clinical review. GP online. 2016. Available from URL: http://www.gponline.com/cellulitis-clinical-review/dermatology/article/1379850.
7. Thomas KS, Brindle R, Chalmers JR, et al. Identifying priority areas for research into the diagnosis, treatment and prevention of cellulitis (erysipelas): results of a James Lind Alliance Priority Setting Partnership. *Br J Dermatol*. 2017; 177: 541-543.
8. Ritchie J, Spencer L. Qualitative data analysis for applied policy research. In B. Bryman & R. Burgess, Analyzing qualitative data. 1994; 173–194.
9. Gale NK, Heath G, Cameron E, et al. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Med Res Methodol*. 2013; 13:117.

Appendix 1

University of Nottingham
UK | CHINA | MALAYSIA

Themes and sub-themes we believe may be described in the study

Key themes	Sub-themes
Diagnosis	Symptoms asked Signs sought Tests done Decision making aids
Challenges	Differential diagnoses Time as a factor Patient expectation Previous experiences Knowledge gap Confidence in making a diagnosis

A qualitative study to determine the health care professionals' experience of the diagnosis of lower limb cellulitis

Final Version 1.0
31.10.2018

Short title:	Diagnosing lower limb cellulitis
IRAS Project ID:	254088
Study Sponsor:	University of Nottingham
Sponsor reference:	18072
Funding Source:	Funding from the RCGP Practitioners allowance will be sought, providing a maximum of £2000. The application form requires the sponsor to agree to act as a research sponsor and so will be submitted after this ethics application has been submitted.

STUDY PERSONNEL AND CONTACT DETAILS

Sponsor:
Contact name
Ms Angela Shone
Research and Innovation
University of Nottingham
East Atrium
Jubilee Conference Centre
Triumph Road
Nottingham
NG8 1DH

Chief investigator:
Professor Kim S Thomas
UoN job title: Professor and Co-Director
Centre of Evidence Based Dermatology
University of Nottingham
Nottingham
NG7 2NR
Phone: 0115 846 8630
Email: mszkst@exmail.nottingham.ac.uk

Co-investigators:
Dr Mitesh Patel
UoN job title:
Academic Clinical Fellow GP ST4
The Tower, University Park
University of Nottingham
Nottingham
NG7 2RD
Phone: 0115 74 86834
Email: msamp9@exmail.nottingham.ac.uk

Professor Joe Kai
UoN job title: Professor and Head of Primary Care
The Tower, University Park
University of Nottingham
Nottingham
NG7 2RD
Phone: 0115 846 67845
Email: mczjk@exmail.nottingham.ac.uk

Professor Paul Leighton
UoN job title:
Associate Professor of Applied Health Services Research
Centre of Evidence Based Dermatology
University of Nottingham
Nottingham
NG7 2NR
Phone: 0115 84 68629

Email: mczpal1@exmail.nottingham.ac.uk

Dr Peter Smart
Patient representative
Centre of Evidence Based Dermatology
University of Nottingham
Nottingham
NG7 2NR
Phone: N/A
Email: smartpeterdr@btinternet.com

Professor Nick J Levell
Consultant Dermatologist
Norfolk and Norwich University Hospital
Norfolk
NR4 7UY
Phone: 01603 288255
Email: nick.levell@nnuh.nhs.uk

Study Coordinating Centre:

Centre of Evidence Based Dermatology
King's Meadow Campus
University of Nottingham
Nottingham
NG7 2NR

SYNOPSIS

Title	A qualitative study to determine health care professionals' experience of the diagnosis of lower limb cellulitis
Short title	Diagnosing lower limb cellulitis
Chief Investigator	Professor Kim S Thomas
Objectives	• Describe the key clinical features which inform the diagnosis of lower limb cellulitis • Explore the difficulties in making a diagnosis of lower limb cellulitis
Study Configuration	Semi-structured interviews with health care professionals regarding lower limb cellulitis
Setting	Primary and secondary care
Number of participants	Approximately 20
Eligibility criteria	Age >18 years All ethnicities Be a qualified health care professional Have managed a clinical case of suspected cellulitis of the lower limb in the UK A minimum of two years clinical experience as a health care professional, which includes managing lower limb cellulitis Able to give informed consent Speak English language
Description of interventions	One face-to-face or telephone interview lasting 45-60 minutes
Duration of study	February 2019- July 2019
Methods of analysis	Framework thematic analysis

ABBREVIATIONS

CI	Chief Investigator overall
CRF	Case Report Form
GCP	Good Clinical Practice
NHS	National Health Service
PI	Principal Investigator at a local centre
PIS	Participant Information Sheet
REC	Research Ethics Committee
R&D	Research and Development department
UoN	University of Nottingham
CEBD	Centre of Evidence Based Dermatology
RCGP	Royal College of General Practitioners

TABLE OF CONTENTS

STUDY BACKGROUND INFORMATION AND RATIONALE

Cellulitis is an acute bacterial inflammation of the dermis and associated subcutaneous tissue, with 60% of cases affecting the lower limb [1]. The diagnosis of cellulitis can be challenging, with 31% of presentations of suspected lower limb cellulitis in the emergency department found to be other diagnoses [2]. Routine biochemical and haematology blood tests and blood cultures are not specific for cellulitis [3]. This results in avoidable hospital admissions and unnecessary antibiotic prescribing [4]. Definitive diagnostic criteria would also improve the validity of clinical research on cellulitis [5], but there are no agreed diagnostic criteria for cellulitis.

Cellulitis cases commonly present to primary care services or the emergency department [6]. A recent cellulitis research priority setting partnership (PSP), ranked questions on 'diagnostic criteria' and identifying early signs and symptoms as important for future cellulitis research [7].

A scoping review we conducted, showed 44 different pathologies misdiagnosed as cellulitis on initial presentation (accepted with changes, British Journal of Dermatology).

A systematic review we carried out, showed that there are no robustly developed and validated diagnostic tools or criteria for lower limb cellulitis (in submission, British Journal of Dermatology). Despite eight potential tools having been explored so far: biochemical tests, imaging, predictive scoring and clinical features, they all provide limited clinical applicability and validity.

No previous qualitative studies have addressed the challenges in diagnosing suspected cellulitis from the health care professionals (HCP) perspective.

STUDY OBJECTIVES AND PURPOSE

PURPOSE

This study will help to establish the core features described by health care professionals (HCP) when they suspect a patient may have lower limb cellulitis. This will also help answer the question ‘what are the early signs and symptoms of cellulitis that can help ensure speedy treatment’: a priority from the cellulitis PSP. Furthermore, this study will also support further research on the development of diagnostic criteria for lower limb cellulitis.

OBJECTIVES

Primary

- Describe the key clinical features which inform the diagnosis of lower limb cellulitis

Secondary

- Explore the difficulties in making a diagnosis of lower limb cellulitis

STUDY DESIGN

STUDY CONFIGURATION

Face-to-face or telephone interviews, lasting approximately 45-60 minutes will be conducted with health care professionals (HCPs). A purposive sample will be selected, with HCPs

(doctors and nurses) from: general practice, dermatology, tissue viability service, lymphoedema service and either the emergency department or acute medicine.

STUDY MANAGEMENT

The study will be managed from the central coordinating centre (CEBD, University of Nottingham).

The Chief Investigator (CI) has overall responsibility for the study and shall oversee all study management.

The data custodian will be the CI.

DURATION OF THE STUDY AND PARTICIPANT INVOLVEMENT

Study Duration: Interviews will start in February 2019 and is expected to be completed by July 2019. The total duration will be six months.

Participant Duration: Each participant will take part in an interview that will last 45-60 minutes. No follow up interviews are planned. Participants will receive a summary of the study findings unless they specifically ask not to receive them. It is anticipated that up to 20 participants will be required, however more HCPs will be included if new themes emerge.

End of the Study

The end of the study will be the last interview.

SELECTION AND WITHDRAWAL OF PARTICIPANTS

Recruitment

Doctors and nurses from: general practice, dermatology, tissue viability service, lymphoedema service and either the emergency department or acute medicine, will be recruited.

Recruitment will be opportunistic in the first instance, using a sampling frame to ensure a broad representation of participants. HCPs will be emailed, briefly discussing the aims of the study, inclusion criteria and methods of the study. HCPs will be approached through:

- A pre-existing cellulitis database, co-ordinated at the Centre of Evidence Based Dermatology (CEBD), which includes general practitioners (GPs), dermatologists, emergency physicians, lymphoedema specialists and nurses. They have previously been involved with cellulitis research at the CEBD and have consented to being approached for future cellulitis studies.
- The UK Dermatology clinical trials network, co-ordinated at the CEBD, includes a broad membership of GPs, dermatologists and nurses who have consented to being approached about future dermatology studies.
- The British Association of Dermatologists, Society of Acute Medicine, Royal College of Emergency Medicine, Nottinghamshire Local Medical Committee for GPs and Primary Care Dermatology Society have agreed to advertise in their newsletters.
- Emergency department and acute medicine physicians/nurses will be recruited from Nottingham University Hospitals NHS Trust, through contacting the clinical leads of each speciality.
- GPs will be recruited by contacting seven clinical commissioning groups (CCG) leads in Nottingham.

- Dermatologists and dermatology nurses will be approached from the cellulitis clinic at Norwich and Norfolk University Hospital, with the help of NL (co-applicant) who helped set up the clinic.
- Snowball sampling where participants help recruit other participants.
- Snowball sampling where current clinical colleagues can help to recruit.
- Additional regulatory bodies such as the Royal College of Nursing and British Lymphology society.

If participation uptake is low, HCPs who have worked with members of the research team will be pragmatically approached. These HCPs will have typical demographics for which we are including in this study.

The local researcher will inform the participant of all aspects pertaining to participation in the study. All HCPs in the UK communicate in English and therefore the consent forms and information sheets will not be available printed in other languages.

It will be explained to the potential participant that entry into the study is entirely voluntary and that they can withdraw at any time but attempts will be made to avoid this occurrence. In the event of their withdrawal it will be explained that their data collected so far cannot be erased and we will use the data in the final analyses where appropriate.

Eligibility criteria

Inclusion criteria

Age >18 years
All ethnicities
Be a qualified health care professional
Have managed a clinical case of suspected cellulitis of the lower limb in the UK
A minimum of two years clinical experience as a health care professional, which includes managing lower limb cellulitis
Able to give informed consent
Speak English language

Exclusion criteria

None

Expected duration of participant participation

Study participants will be participating in the study for 45-60 minutes.

Participant Withdrawal

Participants may be withdrawn from the study at their own request. Participants will be made aware (via the information sheet and consent form) that should they withdraw the data collected to date cannot be erased and may still be used in the final analysis.

Informed consent

The Investigator will contact the participant by email before the interview to explain the details of the study and provide a Participant Information Sheet and Consent Form, ensuring that the

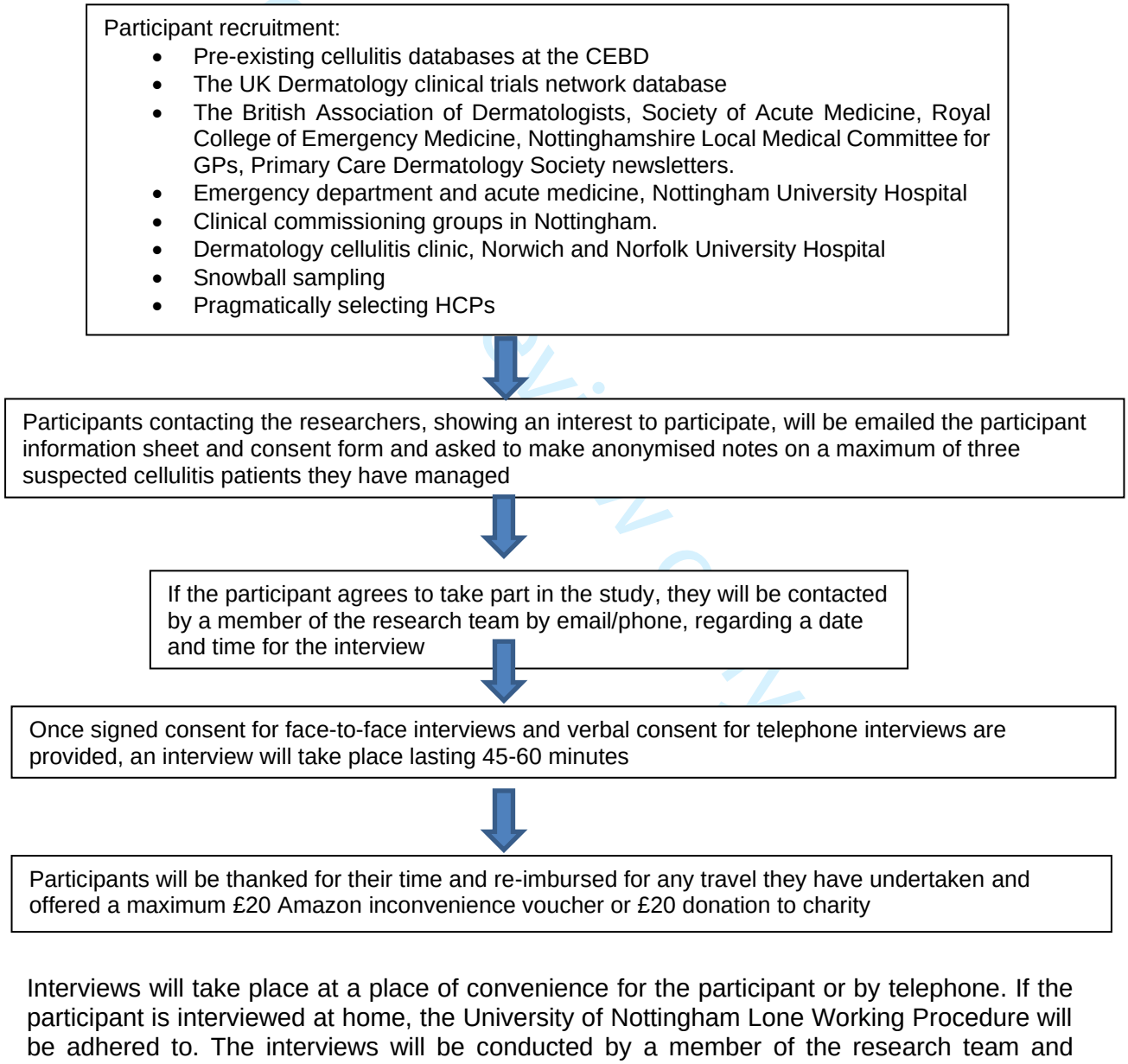
participant has sufficient time to consider participating or not. The Investigator will answer any questions that the participant has concerning study participation.

For participants giving a face-to-face interview, the Consent Form will be signed and dated by the participant before the interview. One copy of the Consent Form will be kept by the participant and one will be kept by the Investigator. On commencing the recording, the participants will be asked to confirm that they have given consent to take part and for the interview to be digitally recorded. For telephone interviews, formal, recorded verbal consent will be gained before the interview and this consent will be transcribed, as a way of documenting this.

STUDY REGIMEN

The individual steps that each participant will undertake are shown in Figure 1:

Figure 1: Study procedure



Interviews will take place at a place of convenience for the participant or by telephone. If the participant is interviewed at home, the University of Nottingham Lone Working Procedure will be adhered to. The interviews will be conducted by a member of the research team and

recorded. Transcription of data will be undertaken by a member of the research team, or a transcription service affiliated with the University of Nottingham. A set series of questions will be used for the first two interviews, but may be adapted based on the findings of these interviews.

Compliance

We do not expect any compliance issues.

Criteria for terminating the study

None.

ANALYSES

Methods

A semi-structured interview guide (see attached document) has been developed around topic themes from existing literature and in our scoping review (see Box 1), however, this is flexible to allow unanticipated themes to emerge. Participants recruited will be asked in the initial email with the participant information sheet and consent form, to make anonymised notes on a maximum of three cases of cellulitis they have managed, to discuss in the interview. They will be asked to make notes on the following topics: signs, symptoms, tests used, challenges encountered with making a diagnosis, learning points for future cases.

Box 1: Interview topic themes

Themes 1: Clinical features of suspected cellulitis

Themes 2: Experiences of diagnosis

All interviews will be audio-recorded and transcribed verbatim, with participant numbers assigned to avoid any personal identifiers.

All idiosyncratic features that add no meaning to the transcript will be removed. The cleaned transcripts will then by formatted for read-in compatibility with the data management software, password protected and stored on the secure server at the University of Nottingham.

The data transcripts will be organised using the qualitative software package QSR NVivo 12. The data will then be handled following the conventions of framework analysis [8]. A broad analytic framework based upon the topic themes and interview questions will be constructed, and subsequently refined by coding a small number of transcripts [9]. Coding will be done by one researcher (MP) and validated by an independent reviewer (JK, KT or PL). All other data will be charted to the refined framework. Once charting has been completed, thematic matrices can be interpreted and summaries of each theme / sub-theme produced (Appendix 1). Comparisons will be made between the data from different specialities.

Data storage

Copies of the audio data files will be uploaded to a secure electronic platform to allow data transfer between the study team and the transcriber. Once the transcripts have been generated, uploaded to the platform, and retrieved by the study team, the audio files will be deleted from the platform. All raw audio data files and transcripts will be encrypted, password protected and stored on a secure server at the University of Nottingham.

Sample size and justification

We approximate that 20 participants will be included as a purposive sample. This number has been chosen because it is feasible to include within the limits of study funding and time. We aim to recruit both doctors and nurses in specialties of general practice, dermatology and either the emergency department or acute medicine, as all these three specialties manage cellulitis frequently. All participants need to have at least two years of clinical experience, as this will include HCPs who have specialist registration and will likely have more clinical experience of cellulitis.

We aim to include an equal number of men and women, with varying number of years of clinical experience as their clinical experiences will change with time. With regards to the GPs and emergency care staff, we want to include both those with more specialist dermatology or infection expertise, and those without.

ADVERSE EVENTS

The occurrence of an adverse event as a result of participation within this study is not expected and no adverse event data will be collected.

ETHICAL AND REGULATORY ASPECTS

If confidential information, defined as information that may identify an individual or place, is shared during the interview, then this will be omitted from the saved copy of the transcript.

The researchers will not impart any medical judgements or opinions. However, if information is shared that may have affected patient safety, then this will be discussed with the CI and escalated as required.

ETHICS COMMITTEE AND REGULATORY APPROVALS

The study will not be initiated before the protocol, consent forms and participant information sheets have received approval / favourable opinion from the Research Ethics Committee (REC), the respective National Health Service (NHS) or other healthcare provider's Research & Development (R&D) department. Should a protocol amendment be made that requires REC approval, the changes in the protocol will not be instituted until the amendment and revised informed consent forms and participant information sheets (if appropriate) have been reviewed and received approval / favourable opinion from the REC and R&D departments. A protocol amendment intended to eliminate an apparent immediate hazard to participants may be implemented immediately providing that the REC are notified as soon as possible and an approval is requested. Minor protocol amendments only for logistical or administrative changes may be implemented immediately; and the REC will be informed.

The study will be conducted in accordance with the ethical principles that have their origin in the Declaration of Helsinki, 1996; the principles of Good Clinical Practice, and the UK Policy Framework for Health and Social Care Research 2017.

INFORMED CONSENT AND PARTICIPANT INFORMATION

The process for obtaining participant informed consent will be in accordance with the REC guidance, and Good Clinical Practice (GCP) and any other regulatory requirements that might be introduced. The investigator and the participant shall both sign and date the Consent Form, for face-to face interviews, before the person can participate in the study. Recorded verbal consent will be taken for telephone interviews before participation and the Consent Form posted after the interview to sign and return to the research team.

The participant will receive a copy of the signed and dated forms and the original will be retained in the Study records.

RECORDS

Case report form

Each participant will be assigned a participant number. There will be one case report form (CRF), keeping a record of all: participant's name, date of birth and participant study number. This form will be stored in a secure file that only the researchers can access. In line with the UoN data storage procedures, data will be stored for at least 7 years.

This CRF will be treated as confidential documents and held securely in accordance with regulations. The CRF shall be restricted to those personnel approved by the CI and recorded as such in the study records.

All paper forms shall be filled in using black ballpoint pen. Errors shall be lined out but not obliterated by using correction fluid and the correction inserted, initialled and dated.

Source documents

Source documents shall be filed at the investigator's site and may include but are not limited to, consent forms, study records, interview transcriptions and audio records. Only study staff shall have access to study documentation other than the regulatory requirements listed below.

Direct access to source data / documents

All source documents shall be made available at all times for review by the CI, Sponsor's designee and inspection by relevant regulatory authorities.

DATA PROTECTION

All study staff and investigators will endeavour to protect the rights of the study's participants to privacy and informed consent, and will adhere to the current UK General Data Protection regulation (GDPR). The CRF will only collect the minimum required information for the purposes of the study. The CRF will be held securely, in a locked room, or locked cupboard or cabinet. Access to the information will be limited to the study staff and investigators and any relevant regulatory authorities. Computer held data including the study database will be held

securely and password protected. All data will be stored on a secure dedicated web server. Access will be restricted by user identifiers and passwords (encrypted using a one way encryption method).

Electronic data will be backed up every 24 hours to both local and remote media in encrypted format.

Any medical information provided will be kept confidential.

QUALITY ASSURANCE & AUDIT

INSURANCE AND INDEMNITY

Insurance and indemnity for clinical study participants and study staff is covered within the NHS Indemnity Arrangements for clinical negligence claims in the NHS, issued under cover of HSG (96)48. There are no special compensation arrangements, but study participants may have recourse through the NHS complaints procedures.

The University of Nottingham as research Sponsor indemnifies its staff, research participants and research protocols with both public liability insurance and clinical trials insurance. These policies include provision for indemnity in the event of a successful litigious claim for proven non-negligent harm.

STUDY CONDUCT

Study conduct may be subject to systems audit for inclusion of essential documents; permissions to conduct the study; CVs of study staff and training received; local document control procedures; consent procedures and recruitment logs; adherence to procedures defined in the protocol (e.g. inclusion / exclusion criteria, timeliness of visits); accountability of study materials and equipment calibration logs.

STUDY DATA

Monitoring of study data shall include confirmation of informed consent; data storage and data transfer procedures; local quality control checks and procedures, back-up and disaster recovery of any local databases.

Study data and evidence of monitoring and systems audits will be made available for inspection by the ethics committee as required.

RECORD RETENTION AND ARCHIVING

In compliance with the University of Nottingham Code of Research Conduct and Research Ethics, the CI will maintain all records and documents regarding the conduct of the study. These will be retained for at least 7 years or for longer if required. If the responsible investigator is no longer able to maintain the study records, a second person will be nominated to take over this responsibility.

The study documents held by the CI on behalf of the Sponsor shall be finally archived at secure archive facilities at the University of Nottingham. This archive shall include all anonymised transcripts, study databases and associated meta-data encryption codes.

DISCONTINUATION OF THE STUDY BY THE SPONSOR

The Sponsor reserves the right to discontinue this study at any time for failure to meet expected enrolment goals, for safety or any other administrative reasons. The Sponsor shall take advice as appropriate in making this decision.

STATEMENT OF CONFIDENTIALITY

Individual participant medical or personal information obtained as a result of this study are considered confidential and disclosure to third parties is prohibited with the exceptions noted above.

If information is disclosed during the study that could pose a risk of harm to the participant or others, the researcher will discuss this with the CI and where appropriate report accordingly.

Data generated as a result of this study will be available for inspection on request by the participating physicians, the University of Nottingham representatives, the REC, local R&D Departments and the regulatory authorities.

PUBLICATION AND DISSEMINATION POLICY

The study results will be published in a peer reviewed academic journal and presented at conferences. All the participants will be sent the results, unless they request not to receive them. The manuscript will follow the Standards for Reporting Qualitative Research (SRQR) recommendations.

Participants will not be identifiable in the dissemination of results.

USER AND PUBLIC INVOLVEMENT

This study was developed from priorities in cellulitis research identified by patients at the cellulitis PSP. A patient with cellulitis, as a collaborator, has helped in the design of this protocol.

The results will also be discussed at the annual CEBD patient panel, with patients with various skin diseases present, including cellulitis.

STUDY FINANCES

Funding source

Funding from the RCGP Practitioners allowance will be sought, providing a maximum of £2000. The application form requires the sponsor to agree to act as a research sponsor and so will be submitted after this ethics application has been submitted.

Participant stipends and payments

Participants will be offered a £20 amazon inconvenience voucher, or a £20 donation to charity on their behalf, to participate in the study. This will ensure a gesture of gratitude, without influencing the participant response.

Travel expenses will be provided for participants to attend a face-to-face interview.

SIGNATURE PAGES

Signatories to Protocol:

Chief Investigator: (name)_____

Signature:_____

Date: _____

REFERENCES

1. Lazzarini L, Conti E, Tositti G, et al. Erysipelas and cellulitis: clinical and microbiological spectrum in an Italian tertiary care hospital. *J Infect*. 2005; 51(5):383-9.
2. Weng QY, Raff AB, Cohen JM, Gunasekera N, Okhovat JP, Vedak P, et al. Costs and Consequences Associated With Misdiagnosed Lower Extremity Cellulitis. *JAMA Dermatology*. 2017; 153(2):141–146.
3. Raff AB, Kroshinsky D. Cellulitis: A Review. *JAMA*. 2016; 316(3):325-337.
4. David CV, Chira S, Eells SJ, et al. Diagnostic accuracy in patients admitted to hospitals with cellulitis. *Dermatol Online J*. 2011 ; 17(3):1.
5. Obaitan I, Dwyer R, Lipworth AD, et al. Failure of antibiotics in cellulitis trials: a systematic review and meta-analysis. *Am J Emerg Med*. 2016; 34(8):1645-52.
6. Lee A, Levell N. Cellulitis: clinical review. GP online. 2016. Available from URL: http://www.gponline.com/cellulitis-clinical-review/dermatology/article/1379850.
7. Thomas KS, Brindle R, Chalmers JR, et al. Identifying priority areas for research into the diagnosis, treatment and prevention of cellulitis (erysipelas): results of a James Lind Alliance Priority Setting Partnership. *Br J Dermatol*. 2017; 177: 541-543.
8. Ritchie J, Spencer L. Qualitative data analysis for applied policy research. In B. Bryman & R. Burgess, Analyzing qualitative data. 1994; 173–194.
9. Gale NK, Heath G, Cameron E, et al. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Med Res Methodol*. 2013; 13:117.

Appendix 1

Themes and sub-themes we believe may be described in the study

Key themes	Sub-themes
Diagnosis	Symptoms asked Signs sought Tests done Decision making aids
Challenges	Differential diagnoses Time as a factor Patient expectation Previous experiences Knowledge gap Confidence in making a diagnosis

BMJ Open

An interview study to determine the experiences of cellulitis diagnosis amongst health care professionals in the UK.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-034692.R1
Article Type:	Original research
Date Submitted by the Author:	23-Mar-2020
Complete List of Authors:	Patel, Mitesh; University of Nottingham, ; Lee, Siang Ing; University of Nottingham, Nottingham, UK, Division of Primary Care & National Institute for Health Research, School of Medicine, Levell, Nick; Norfolk and Norwich University Hospital NHS Foundation Trust, Dermatology Smart, Peter; University of Nottingham, Nottingham, UK Kai, Joe; University of Nottingham, Nottingham, UK Thomas, Kim; University of Nottingham, Centre of Evidence Based Dermatology Leighton, Paul; University of Nottingham, Centre of Evidence Based Dermatology
Primary Subject Heading:	Dermatology
Secondary Subject Heading:	Infectious diseases, Qualitative research
Keywords:	DERMATOLOGY, Adult dermatology < DERMATOLOGY, Infectious diseases & infestations < DERMATOLOGY, QUALITATIVE RESEARCH

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Title: An interview study to determine the experiences of cellulitis diagnosis amongst health care professionals in the UK.

Running head: Cellulitis diagnosis by health care professionals

Word count: 3262

Table count: 3

Figure count: 1

Supplementary materials: Figure 1, Table 1

Authors: M Patel, [1,2] S I Lee, [1] NJ Levell, [3] P Smart, [4] J Kai, [1] KS Thomas, [2] P Leighton, [2]

[1] Division of Primary Care & National Institute for Health Research, School of Medicine, University of Nottingham, Nottingham, UK

[2] Centre of Evidence Based Dermatology, University of Nottingham, Nottingham, UK

[3] Dermatology Department, Norfolk and Norwich University Hospital NHS Trust, UK

[4] Patient representative, Centre of Evidence Based Dermatology, University of Nottingham, Nottingham, UK

ORCID ID: M Patel (0000-0003-3975-4689), SI Lee (0000-0002-2332-5452), NJ Levell (0000-0003-3393-8305), J Kai (0000-0001-9040-9384), KS Thomas (0000-0001-7785-7465), P Leighton (0000-0001-5208-0274),

Corresponding author: Mitesh Patel, Division of Primary Care, School of Medicine, University of Nottingham, Nottingham, UK, Email: mpatel59@doctors.org.uk

Funding sources: This study was supported by the Scientific Foundation Board of the Royal College of General Practitioners (grant SFB 2018 – 31).

Study registration: Centre of Evidence Based Dermatology website - https://www.nottingham.ac.uk/research/groups/cebd/documents/researchdocs/protocol-diagnosing-lower-limb-cellulitis-health-care-professionals.pdf

Data sharing: No additional data available

Abstract

Objectives: To explore health care professionals (HCPs) experiences and challenges in diagnosing suspected lower limb cellulitis.

Setting: UK nationwide.

Participants: 20 qualified HCPs, who had a minimum of two years clinical experience as a HCP in the national health service and had managed a clinical case of suspected cellulitis of the lower limb in the UK. HCPs were recruited from departments of dermatology (including a specialist cellulitis clinic), general practice, tissue viability, lymphoedema services, general surgery, emergency care and acute medicine. Purposive sampling was employed to ensure that participants included consultant doctors, trainee doctors and nurses across the specialties listed above. Participants were recruited through: national networks,

HCPs who contributed to the cellulitis priority setting partnership (PSP), UK Dermatology Clinical Trials Network, snowball sampling where participants helped recruit other participants, personal networks of the authors.

Primary and secondary outcomes: Primary outcome was to describe the key clinical features which inform the diagnosis of lower limb cellulitis. Secondary outcome was to explore the difficulties in making a diagnosis of lower limb cellulitis

Results: The presentation of lower limb cellulitis changes as the episode runs its course. Therefore, different specialties see clinical features at varying stages of cellulitis. Clinical experience is essential to being confident in making a diagnosis, but even amongst experienced HCPs, there were differences in the clinical rationale of diagnosis. A group of core clinical features were suggested, many of which overlapped with alternative diagnoses. This emphasises how the diagnosis is challenging, with objective aids and a greater understanding of the mimics of cellulitis required.

Conclusion: Cellulitis is a complex diagnosis and has a variable clinical presentation at different stages. Although cellulitis is a common diagnosis to make, HCPs need to be mindful of alternative diagnoses.

Keywords: lower limb, cellulitis, diagnosis, health care professionals

Article summary

Strengths and limitations of this study

- Participants were included nationally around the UK, across various specialities that commonly diagnose cellulitis, with both nurses and doctors of varying clinical experience.
- A small sample size was recruited, which limits the generalisability of our findings.
- Those with a specialist interest in dermatology were more likely to be recruited, which may not be representative of the views of all health care professionals.
- Some participants were unable to fully describe their clinical rationale behind diagnostic decisions during the interview.
- Interviewees may not have fully shared the details of cases that were misdiagnosed or where diagnoses were delayed due to social desirability bias or fear of litigation.

Introduction

Cellulitis is a frequent presentation in both the community and secondary care, with 60% of presentations affecting the lower limbs.[1] However, the diagnosis of cellulitis can be challenging, with up to a third of suspected lower limb cellulitis cases being later diagnosed as other diagnoses.[2] This results in avoidable hospital admissions and unnecessary antibiotic prescribing [3] and is further compounded by the lack of validated diagnostic criteria or tools for cellulitis.[4]

A UK cellulitis research priority setting partnership (PSP) determined that improving health care professionals' (HCPs) diagnostic accuracy is a key priority for future cellulitis research.[5] An interview study of people with recurrent cellulitis and lymphoedema suggested that patients often experience difficulties in obtaining a speedy and accurate diagnosis. [6]

The aims of this interview study were to explore the HCP experiences and challenges faced in diagnosing suspected lower limb cellulitis.

Methods

Protocol registration and Ethics

The final protocol was registered on the Centre of Evidence Based Dermatology (CEBD) website (9 May 2019). Ethical approval was granted by the Health Research Authority and Health and Care Research Wales (19/HRA/0485) (30 November 2018). Verbal and written consent was obtained from each participant.

Patient and public involvement

The research question was developed from research priorities in the cellulitis PSP, involving patients. A patient representative helped design this study and is a co-author. On publication, participants will be sent the final manuscript.

Eligibility criteria

Selection of participants

Participants were qualified HCPs, who had a minimum of two years clinical experience as a HCP in the national health service (NHS) and had managed a clinical case of suspected cellulitis of the lower limb in the UK. Two year's experience was the minimum requirement as then HCP's will have gained adequate exposure to cellulitis cases. HCPs were recruited from departments of dermatology (including a specialist cellulitis clinic), general practice, tissue viability, lymphoedema services, general surgery, emergency care and acute medicine.

Purposive sampling was employed to ensure that participants included consultant doctors, trainee doctors and nurses across the specialties listed above. Participants were recruited through:

- National networks
- HCPs who contributed to the cellulitis PSP
- UK Dermatology Clinical Trials Network
- Snowball sampling where participants helped recruit other participants
- Personal networks of the authors

Potential participants were approached and recruited by email. Data collection and analysis were undertaken concurrently and sampling ceased when thematic saturation had been achieved (i.e. new interviews generated no new insights).[7]

Researcher characteristics

Interviews were conducted by MP (male), and coded and analysed by MP and SIL (female) (both general practitioner (GP) trainees who had managed clinical cases of cellulitis previously). Both MP and SIL attended qualitative methodology training courses. The broader research group included experienced clinical-academics (JK (academic GP) and NL (clinical professor of dermatology), a patient representative (PS) and senior qualitative experts (JK and PL). Three participants had clinical interactions with the interviewer in the past, but not regarding cellulitis.

Interview setting

Each participant took part in a single, semi-structured, qualitative interview. Two interviews were face to face, with the remaining via telephone. Written consent was gained from participants, with additional verbal consent gained before the interview. All participants received a £20 reimbursement voucher or donated this fee to the British Skin Foundation charity.

Data collection

Prior to the interview, participants were asked to reflect upon their most recent experiences of making a cellulitis diagnosis, focusing on the typical presentations, challenging cases and differential diagnoses.

A topic guide, informed by a prior systematic review and interview study,[8] was used to structure the interview (Supplementary materials, Figure 1). However, participants were urged to propose and/or expand on topics which they felt were relevant to their experience of diagnosis. New topics were then added to the topic guide for subsequent interviews.

Data processing

Interviews were audio-recorded and transcribed. Transcripts were checked (by MP) and data managed using QSR NVivo 12 software.

Data analysis

Analysis was inductive, searching for themes in the data. A structured, systematic, multi-stage approach to thematic analysis was followed.[9] Coders immersed themselves in the data, by reading the data set before coding. Data were coded manually by MP, with SIL also independently coding a third of the transcripts. A list of each code, with a brief description was then used to group the codes into theme-piles. Themes were defined and refined, with sub-themes also developed.

Uncertainties in coding and thematic organisation were resolved in discussion with the other authors. Data collection and analysis was concurrent. The final codebook was agreed by all authors and is presented in Figure 1. The interviewer kept a reflexive research diary, logging intuitive thoughts and immediate reflections after each interview. These reflections, as well as queries around data collection, handling and interpretation were then discussed at regular research meetings.

Results

Twenty HCPs were interviewed (Table 1). Interviews were conducted between 19 March and 11 June 2019, with a mean duration of 29 minutes.

Table 1: Characteristics of the participants

Participant	Ethnicity	Clinical role	Number of times they have diagnosed cellulitis	Time since they last diagnosed cellulitis
1	British Asian	GP	>50	One week ago
2	British Caucasian	Acute medicine/infectious disease consultant	>50	One week ago
3	Irish Caucasian	GP	>50	Three weeks ago
4	British Caucasian	Acute medicine consultant	>50	Last four weeks
5	British Caucasian	Acute medicine consultant	>50	One week ago

6	British Caucasian	Tissue viability nurse	10-50	Less than one week
7	British Caucasian	Lymphoedema specialist nurse	>50	One week ago
8	British Asian	Emergency medicine consultant	>50	Less than one week
9	British Asian	Dermatology consultant	10-50	Four weeks ago
10	British Caucasian	District nurse	>50	Last three months
11	Black	GP trainee	10-50	Less than one week
12	British Asian	GP locum	10-50	Two weeks ago
13	British Asian	GP out of hours	>50	Two weeks ago
14	British Caucasian	Dermatology specialist nurse	>50	Last three months
15	British Caucasian	Dermatology consultant	10-50	Last 12 months
16	Mixed	Surgical trainee	10-50	Last four weeks
17	British Caucasian	Community advanced nurse practitioner	>50	Less than one week
18	British Caucasian	Dermatology trainee	>50	Four weeks ago
19	British Caucasian	Emergency medicine consultant	>50	Last three months
20	British Caucasian	Dermatology consultant	>50	Less than one week

183

Main findings

Themes	Sub-themes	Codes
The patient	The typical patient and	• Typical cellulitis presentations

Four key themes were identified: 1) The patient presentation; 2) Challenges leading to diagnostic uncertainty; 3) Strategies to improve diagnosis; 4) The need for an objective diagnostic aid, with further classification into sub-themes. How the codes mapped onto the overarching themes are shown in Table 2. Quotes from participants are shown in Supplementary Table 1.

Table 2: How the codes mapped onto themes

presentation	risk factors	• Factors that increase the likelihood of cellulitis diagnosis
	Confidence in diagnosis	• Most suitable HCP to diagnose cellulitis •
		• Experience guides diagnosis
	Cases of misdiagnoses	• Missed/delayed diagnosis of cellulitis (final diagnosis)
		• Missed/delayed diagnosis of cellulitis (initial diagnosis)
	Differential diagnoses	• List of alternative diagnosis
Challenges leading to diagnostic uncertainty	Continuum of clinical features	• Changes in clinical presentation
	A subjective diagnosis	• Reasons why cellulitis diagnosis is challenging
	Community challenges	• Seeing patients part way through assessment and management
		• Follow up of patients
	The role of 'defensive' medicine	• Sepsis as a concern
		• Medico legal issues as a factor
		• Fear of missing more serious differentials
	Patient specific factors	• Other factors influencing diagnosis
Strategies to improve diagnosis	Using time as a guide	• Time and safety netting approach •
	Trial of treatment	• Trial of treatment guides diagnosis •
	Biochemical investigations	• Investigations to aid diagnosis

	Seeking advice	• Discussing diagnosis with colleagues
	Further education	• Suggestions on what may improve diagnosis
The need for an objective diagnostic aid	A diagnostic algorithm	• Views on diagnostic aids for HCP
	Indices for an algorithm	• Clinical features to include in diagnostic algorithm

Diagnosis of cellulitis

The typical patient and risk factors

In general practice, the typical patient described by participants included older adults with co-morbidities; concerns of possible cellulitis cases were often raised by district nursing colleagues. Emergency care and acute services described people who presented with features of systemic compromise. Both infectious disease and general surgery services often managed intravenous drug users who were at risk of deeper infection.

Factors that HCPs stated increased the likelihood of cellulitis were: features of systemic upset including fever, malaise, rigors; co-existing injury or infection such as tinea, superficial ulceration, previous history of cellulitis, previous history of dermatological conditions such as eczema, diabetes, immunosuppressive medications and those with no fixed abode with social and health

risks. Bilateral symptoms were commonly described by participants as a factor increasing the likelihood of chronic, systemic pathologies rather than cellulitis.

Confidence in diagnosis

One dermatologist explained how being more aware of the differential diagnoses made them more likely to accurately diagnose cellulitis, especially compared to junior colleagues . Generally, HCPs with more clinical experience felt more confident with diagnosis, as they appreciated the presentation with more observed cases.

A dermatology trainee felt seeing less cellulitis cases during their training compared to their senior colleagues historically and therefore not getting as much exposure hindered accurate diagnosis.

Cases of misdiagnoses

Trauma related skin changes was frequently an initial misdiagnosis in the emergency department. When discussing cases of uncertainty, where cellulitis was the initial suspected diagnosis, one GP described a case of venous eczema which was managed with repeated antibiotics. Chronic rashes were frequently seen by dermatology and infectious disease discussed lymphoma cases initially referred as cellulitis.

The importance of a correct diagnoses is key, as two participants discussed the possibility of prophylactic antibiotics for patients with recurrent cellulitis. A dermatology consultant explained how misdiagnosis can result in inappropriate and costly admissions to the ward.

Differential diagnoses

A frequent diagnosis of uncertainty for primary and emergency care was DVT, as the clinical features of cellulitis can overlap. Common differential diagnoses discussed by participants, which they observed in their clinical practice, with discriminating features from cellulitis that they described, are shown in Table 3.

Table 3: Differential diagnoses of lower limb cellulitis discussed by participants

Differential diagnoses	Key differentiating factors from cellulitis
Chronic heart failure causing oedema	Chronic, bilateral, lack of mobility, breathless, cardiac history (P1,GP;P14,dermatology specialist nurse)
Venous eczema	Usually chronic with hemosiderin scaling, itching, crusting, likely bilateral, possibly eczema elsewhere on body, less well defined, (P3,GP;P15, dermatology consultant)

Thrombophlebitis	Tender, localised, hard, lumpy rash around an often-thickened vein (P3,GP;P5,acute medicine consultant;P12,GP locum)
Erythema nodosum	Multiple, discrete swellings (P13,GP out of hours)
Deep vein thrombosis	Pain is usually deep in calf rather than superficial, less sharply demarcated and less intense erythema, diffuse swelling of limb, can be young, can be intravenous drug users, high DVT wells score, fewer systemic features (P2,infectious disease consultant;P12,GP locum;P13,GP out of hours)
Lymphoedema	Chronic, bilateral, usually less painful, thickened warty skin in the long-term, normal inflammatory markers (P9,dermatology consultant;P18,dermatology trainee)
Allergic reaction to insect bites	Central puncture mark, itch, when acute, developing lichenified erythema when chronic (P2,infectious disease consultant)
Lipodermatosclerosis	Often bilateral, systemically well, tight non tender skin with inverted champagne bottle appearance (P4,acute medicine consultant; P20,dermatology consultant)
Necrotising fasciitis	Crepitus, rapidly spreading, septic, very tender (P5,acute medicine consultant; P16, surgical trainee)
Wound infection	Local to the wound, covers small area, yellow exudate, strong odour (P10,district nurse; P16,surgical trainee)

Baker's cyst	Unilateral popliteal swelling, suddenly more tender on rupture (P15,dermatology consultant)

Challenges leading to diagnostic uncertainty

The continuum of clinical features

Participants described how the presentation of lower limb cellulitis changed as the episode ran its course. This was influenced by when patients seek clinical review and meant that different specialties observed clinical features at varying stages of cellulitis.

In dermatology services, presentations were seen later in the episode. However, partial treatment and response did make the diagnosis challenging as the initial typical features of cellulitis may then vary. However, seeing patients later in the journey allowed dermatologists to appreciate the progression of clinical features. Importantly for dermatologists, other more serious pathologies such as a deep vein thrombosis (DVT) had often been ruled out.

A subjective diagnosis

One GP explained how there is no specific test that can aid diagnosis, thus subjective assessment can lead to different diagnoses. She added how this is further influenced by previous experiences, including how long and where HCPs have trained.

Community challenges

In the community, additional challenges for GPs were not being familiar with the patient's background history, seeing a patient for the first time, or taking over care part way through the patient journey. Working as a locum doctor with a lack of follow up available, often led to treatment when unsure of the diagnosis. Limited resources to see patients, such as not being able to conduct an urgent home visit, also influenced diagnosis and subsequent management by GPs.

The role of 'defensive' medicine

HCPs in the community, emergency care and surgery were particularly wary of missing a more serious diagnosis, which needed to be ruled out first, such as DVT and necrotising fasciitis (NF). Many HCPs also mentioned '*sepsis*' when discussing clinical features and diagnosis. This may be leading to an over diagnosis of cellulitis due to concerns of medico legal complaints of missing an infection which could then get worse.

Patient specific factors

Participants found people with pigmented skin, lymphoedema and with nonspecific symptoms particularly difficult to diagnose in the acute setting. One nurse described another diagnostic challenge was when a patient presents with chronic skin changes or a recent episode of cellulitis with continuing signs.

Strategies used to reduce uncertainty

Using time as a guide

In cases where the HCP was not sure of the diagnosis, different strategies were employed. Using time to allow further clinical features to develop, with appropriate safety netting was a commonly used approach. This was easier when follow-up appointments were available in the community, but was also done in the acute setting . But follow-up in secondary care was difficult, often not done and can be a missed opportunity to learn from incorrect diagnoses previously.

Trial of treatment

Some HCPs started antibiotics for a suspected cellulitis and reviewed the response to help provide the diagnosis retrospectively. A major concern highlighted by one GP with this approach was antibiotic resistance and side effects. However, overall, there was a common understanding in primary care why this approach was taken in some instances.

Biochemical investigations

In primary care, one doctor described how blood tests and cultures were rarely done to diagnose cellulitis, as such patients would need to be seen in secondary care. Blood cultures were requested by the infectious disease physician if it was an atypical infection, but a challenge described by one dermatology consultant was that organisms are not isolated in the majority of patients. Swabs were done for discharging wound infections, mainly by district nurses or prior to discussion with microbiology, when see by dermatologists.

An emergency physician and surgical trainee explained how blood tests and imaging such as x-rays are important to check for osteomyelitis. The blood tests commonly requested by secondary care HCPs were white cell count (WCC) and C-reactive protein (CRP) for infection with one dermatologist stating how changes in blood test results were important when taking referrals for suspected cellulitis. However, one challenge with interpreting blood tests was in the group partially treated with antibiotics, who have improving blood tests but limited clinical response. A biomarker or point of care test for cellulitis were suggested as investigations to aid diagnosis by one dermatology consultant and one GP respectively.

Seeking advice

Another approach during uncertainty was to discuss with colleagues. In the community the nurse may ask the GP to review and vice versa. In hospital, specialists in infectious disease, dermatology, microbiology and general/plastic surgeons are most often contacted for review.

Further education

Many HCPs mentioned teaching sessions to improve diagnosis, both at the undergraduate and postgraduate level. One GP stated that real life clinical cases were felt to be important for teaching, rather than focusing on pictures.

A dermatology consultant suggested that a key area of education amongst HCPs was being aware of differential diagnoses for the first point of access services. One trainee who worked in a specialist cellulitis clinic found that seeing many cases helped improve her recognition of cellulitis.

The need for an objective diagnostic aid

A diagnostic algorithm

Many participants mentioned developing a diagnostic algorithm, similar to the Wells score for DVT. A GP explained how this may also help GPs make a validated clinical decision when colleagues such as district nurses are suspecting cellulitis and the patient cannot be seen quickly.

A dermatology nurse described how she often used checklists and how an algorithm would help

HCP's not to miss any clinical features. One dermatology consultant suggested that a diagnostic checklist should be more of an educational tool to help rule out other differential diagnoses.

A dermatology trainee felt that the indices of a checklist would have to reflect how cellulitis changes through the course of the episode. Other challenges described by participants, regarding developing an algorithm were the number of alternative diagnoses, with features that often overlapped with cellulitis and vague initial features. Another concern highlighted by a dermatology consultant was that algorithms will miss patients who may present with atypical features, referred to as '*outliers*'.

Indices for an algorithm

The key clinical features HCPs suggested to include in a diagnostic algorithm for lower limb cellulitis were: unilateral, pain, erythema, warmth of limb, pyrexia, swelling, acute onset, trauma to the limb, break in the skin, single area affected, clear demarcation, exudate, flu like malaise, tracking rash, shiny, tenser skin, previous cellulitis, co-existing immunosuppression, co-existing skin conditions, clinical observations for sepsis, negative Wells score and patient concern. No HCP suggested blood tests were a priority in the algorithm, but a GP trainee suggested it could be included in a modified algorithm in secondary care, similar to the CURB-65 score used for pneumonia.

Discussion

Summary

This study found that the presentation of lower limb cellulitis changes as the episode progresses, leading to variation in the clinical features, seen in different clinical settings. This may be reflected in the range of typical differential diagnoses that specialities discussed and has been described in literature.[10]

Clinical experience was described as an important factor in making a more accurate diagnosis. Dermatologists have previously been suggested as the ideal HCP to diagnose cellulitis.[11] However, the clinical reasoning behind a diagnosis were contradictory between some HCPs.

A core group of clinical features to diagnose cellulitis were suggested. But the challenge is that these features can overlap with other pathologies, irrespective of how likely these are.[12] More serious pathologies then need to be ruled out first, both for the safety of the patient and to avoid medico-legal consequences.

Suggestions to improve the accuracy of diagnoses included developing a diagnostic algorithm which could objectively help HCPs with different levels of experience.[13] The challenge with a

diagnostic algorithm is that it would need to incorporate the various stages of a cellulitis episode and therefore various versions of an algorithm might be required.

Importantly, having a greater understanding of the alternative diagnoses is required, especially when the features are vague, atypical or not responding to antibiotic treatment. Educating both doctors and nurses, using real life clinical scenarios and a focus on differential diagnoses, was also discussed and may be an initial feasible approach to improve diagnostic accuracy. A visually based computerized diagnostic decision support system, focusing on differential diagnoses, has been shown to improve the diagnostic accuracy of cellulitis. [14]

Strengths and limitations

A key strength of this study that participants were included nationally around the UK, across various specialities that commonly diagnose cellulitis, with both nurses and doctors of varying clinical experience.

The major limitation of this study was the small sample size and therefore findings may not be generalisable. This stems from the pragmatic design and feasibility of the study. The participants in this study were mainly female doctors. This may not be representative of the workforce in non-UK countries; therefore the transferability of our findings may be limited. In addition, as our

recruitment strategy is most likely to have targeted HCP's with an interest in dermatology, their views may not be representative of other HCPs.

Furthermore, some participants were unable to fully describe their clinical rationale behind diagnostic decisions during the interview. This may be because they have developed an intuitive, pattern-recognition, approach in decision-making with experience. Such heuristic diagnostic processes in dermatology are well documented. [15]

As the interviewer was a fellow clinician, interviewees may not have fully shared the details of cases that were misdiagnosed or where diagnoses were delayed due to social desirability bias or fear of litigation. Clinical researcher bias was unavoidable, as the interviewer had clinical insight into cellulitis. However, non-clinicians within the broader authorship group were also involved with coding and analysis of the interviews.

Three participants were known to the interviewer, which can lead to response bias, however the interviewer felt this also allowed an honest, open discussion.

Comparison with existing literature

To our knowledge, this is the first interview study undertaken with health care professionals, discussing their experiences of cellulitis diagnosis. Our findings on the clinical features of cellulitis,

differential diagnoses and also the need to be aware of mimics have been described in previous review articles.[10] A previous review also described cases of misdiagnosis and emerging approaches to improve diagnoses, [8,16] which were echoed in this study. The diagnostic challenges of infection in primary care, due to atypical presentations and lack of diagnostic tests has previously been described.[17] Using treatments such as antibiotics as diagnostic aids and discussing with colleagues when uncertain about a diagnosis are common strategies. [18,19] Litigation and fear missing a diagnosis has also been well documented in literature. [20]

Implications for research and practice

This study has highlighted that HCPs need to be aware that cellulitis can present with different features at various stages of the acute episode and need to consider the cellulitis mimics. With a current shift in health care resulting in trained nurses now managing more acute presentations, [21] upskilling nurses in cellulitis could be part of the solution.

Many HCPs felt confident in making an accurate diagnosis, often guided by experience and intuition, but found it difficult to verbalise the key distinguishing features. This makes it difficult for the clinical experience to be shared amongst other colleagues, especially less experienced or junior HCPs. Acquiring this insight is important to improve diagnostic accuracy, which can prevent

avoidable antibiotic prescribing and hospital admissions. To overcome this, further qualitative research is required to identify the clinical reasoning behind the expert process of making a diagnosis, perhaps using clinical cases and pictures. This will form the basis of the proposed solution of focused education and clinical features to be included in a diagnostic aid. The challenge with further education for HCPs is that information needs to be accessible for everyone, whilst information overload can lead to a reduction in the quality of decisions. [22]

Some indices and risk factors for a diagnostic algorithm have been identified in this study and previous studies, [23] as well as key distinguishing features from differential diagnosis, but these need validating with larger studies and an expert consensus setting exercise.

Conclusion

This interview study has shown that cellulitis is a complex diagnosis. Not only does the core features overlap with other diagnoses, the presentation of cellulitis changes as the episode progresses. Although cellulitis is a common diagnosis to make, and whilst further research in developing diagnostic aids needs to be undertaken, simply being aware of the cellulitis mimics may help improve diagnostic accuracy.

Acknowledgements

We would like to thank the participants who were interviewed and the professional transcriber Claire Poxon. We also want to thank the Royal College of General Practitioners for supporting this study. The views expressed in this paper are those of the authors and not necessarily those of the National Health Service, the National Institute for Health Research or the Department of Health.

Competing interest

None declared

Author contributions

M Patel was involved with the design of the study, collection and analysis of data, drafting the manuscript and final approval of the manuscript.

S I Lee was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

NJ Levell was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

P Smart was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

J Kai was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

KS Thomas was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

P Leighton was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

References

1 Lazzarini L, Conti E, Tositti G, et al. Erysipelas and cellulitis: clinical and microbiological spectrum in an Italian tertiary care hospital. *J Infect* 2005; **51**(5):383-9.

2 Weng QY, Raff AB, Cohen JM, et al. Costs and Consequences Associated With Misdiagnosed Lower Extremity Cellulitis. *JAMA Dermatol* 2017; **153**(2):141–146.

3 David CV, Chira S, Eells SJ et al. Diagnostic accuracy in patients admitted to hospitals with cellulitis. *Dermatol Online J* 2011 ; **17**(3):1.

4 Patel M, Lee SI, Akyea RK, et al. A systematic review showing the lack of diagnostic criteria and tools developed for lower limb cellulitis. In print: *Br J Dermatol* 2019.

5 Thomas KS, Brindle R, Chalmers JR, et al. Identifying priority areas for research into the diagnosis, treatment and prevention of cellulitis (erysipelas): results of a James Lind Alliance Priority Setting Partnership. *Br J Dermatol* 2017; **177**:541-543.

6 Patel M, Lee SI, Levell NJ, et a. Confidence of recurrent cellulitis self-diagnosis among people with lymphoedema: a qualitative interview study. *Br J Gen Pract 2020*; 70(691).

7 Guest G, Bunce A, Johnson L. How many interviews are enough? An experiment with data saturation and variability. *Field Methods* 2006; 18(1): 59–82.

8 Patel M, Lee SI, Thomas KS, Kai J. The red leg dilemma: a scoping review of the challenges of diagnosing lower - limb cellulitis. *Br J Dermatol* 2019; **180**: 993-1000.

9 Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol* 2006; **3**: 77-101.

10 Bailey E, Kroshinsky D. Cellulitis: diagnosis and management. *Dermatol Ther 2011*; **24**(2):229-239.

11 Levell NJ, Wingfield CG, Garioch JJ. Severe lower limb cellulitis is best diagnosed by dermatologists and managed with shared care between primary and secondary care. *Br J Dermatol 2011;* **164**(6):1326-8.

12 Raff AB, Kroshinsky D. Cellulitis: A Review. *JAMA 2016;* **316**(3):325-37.

13 Pallin DJ, Bry L, Dwyer RC, et al. Toward an Objective Diagnostic Test for Bacterial Cellulitis. *PLoS One 2016*; **11**(9):e0162947.

14 David CV, Chira S, Eells SJ et al. Diagnostic accuracy in patients admitted to hospitals with cellulitis. *Dermatol Online J* 2011; **17**(3):1.

15 Lowenstein EJ. Dermatology and its unique diagnostic heuristics. *JAMA Dermatol* 2018; **78**(6):1239-1240.

16 Edwards G, Freeman K, Llewelyn MJ, Hayward G. What diagnostic strategies can help differentiate cellulitis from other causes of red legs in primary care? *BMJ 2020*; **368**:m54.

17 McKelvie S. Moore A, Croxson C, et al. Challenges and strategies for general practitioners diagnosing serious infections in older adults: a UK qualitative interview study. *BMC Fam Pract 2019;* **20(**56).

18 Hayward GN, Moore A, Mckelvie S, et al. Antibiotic prescribing for the older adult: beliefs and practices in primary care. *J Antimicrob Chemother 2019*;74(3):791-797.

19 Alam R, Cheraghi-Sohi S, Panagioti M, et al. Managing diagnostic uncertainty in primary care: a systematic critical review. *BMC Fam Pract 2017*;**18**(1):79.

20 Birks Y, Aspinal F, Bloor K. Understanding the drivers of litigation in health services. The Kings Fund 2018. University of York.

21 Imison C, Castle-Clarke S, Watson R. Reshaping the workforce to deliver the care patients needs. Research Report. 2016. Nuffield Trust.

22 Kumar A, Maskara S. Coping up with the Information Overload in the Medical Profession. *J Biosci Med 2015*; **3**(11):214-127.

23 Quirke M, Ayoub F, McCabe A, et al. Risk factors for nonpurulent leg cellulitis: a systematic review and meta-analysis. *Br J Dermatol 2017*;**177**(2):382-394.

Figure 1: Standardised codebook used by two independent coders

Supplementary Materials

Figure 1: Topic guide used to structure the interview

Table 1: Quotes provided by participants, mapped onto both the themes and sub-themes

Codes used

- Trial of treatment guides diagnosis
- Discussing diagnosis with colleagues
- Time and safety netting approach
- Patients who self-diagnose and treat
- Approach when HCPs do not agree with patient self-diagnosis
- Patients involved with diagnosis with the HCP
- Typical cellulitis presentations
- Clinical features of cellulitis
- Factors that decrease the likelihood of cellulitis diagnosis
- Factors that increase the likelihood of cellulitis diagnosis
- Investigations to aid diagnosis
- Missed/delayed diagnosis of cellulitis (final diagnosis)
- Missed/delayed diagnosis of cellulitis (initial diagnosis)
- Patient finds it difficult to accept it is not cellulitis
- Reasons why cellulitis diagnosis is challenging
- Suggestions on what may improve diagnosis
- Views on diagnostic aids for HCP
- Views on diagnostic aids for patients
- Views on how well HCP make diagnosis
- Experience guides diagnosis
- Seeing patients part way through assessment and management
- Differential diagnoses
- Sepsis as a concern
- Medico legal issues as a factor
- Follow up of patients
- Most suitable HCP to diagnose cellulitis
- Fear of missing more serious differentials
- Clinical features to include in diagnostic algorithm
- Other factors influencing diagnosis

If the participant has a recent case of cellulitis that they can discuss:

Can you tell me about a case of cellulitis that you diagnosed?

Prompts:

- What thoughts go through your head when you are considering a diagnosis of cellulitis?
- What symptoms do you ask about? Local? General?
- What signs do you look for? Local? General?
- Are there any specific signs/symptoms you rely on to help?
- Did you do any tests?
- Did you seek advice from anyone else?
- Were you concerned that this may not be cellulitis?
- If you were concerned, why?
- Was there anything challenging about this case?
- How did you address these challenges?
- How confident were you that this was cellulitis on a 1-10 scale when you first saw the patient?
- Did the patient discuss any self-diagnoses?
- Did any external factors such as time influence your decision?
- Did the patient come back to see you again?
- Would you change your approach if the same case presented again?
- Is this a typical case you see?
- What are the main differential diagnoses you see?

Repeat the above for a maximum two cases that the participants may have for the interview (repeat twice only if the participant has no delayed/incorrect cases below).

If the participant has a case where the diagnosis was delayed or incorrect (can be initially either seen by same health care professional or a colleague, but preferably the same person)

Prompts:

- Did you see the patient on initial presentation or was it a colleague?
- If it was another colleague, what specialty did they work in?
- What symptoms did they present with?
- What signs did they have?
- What was the initial diagnosis? And why?
- Were any tests done?
- Did any external factors influence the decision for the initial diagnosis?
- When did they see you or another colleague again?
- If it was another colleague, what specialty did they work in?
- Did anything change with the signs/symptoms?
- What happened next?
- Do you know what the final diagnosis was?
- What were the reasons for the delay in the diagnosis?
- Why was it difficult to make an accurate diagnosis on first consultation?

We want to establish if it is possible to determine a core group of features that can be used to help diagnose lower limb cellulitis

Prompts:

- What symptoms are you asking about?

- Of these symptoms, which do you think are more suggestive of cellulitis?
- Are there any symptoms that make cellulitis less likely?
- Are there other features in the history which make cellulitis more/less likely? (prompt – other conditions, previous history, drugs, family history)
- What signs are you looking for?
- Of these signs, which do you think are more suggestive of cellulitis?
- Would you request any tests if it was available to you on the same day?
- If so what tests would these be?
- Are there any signs in a 'red leg' that would make cellulitis less likely as the diagnosis?
- Are there any signs in a red leg which would make cellulitis more likely as the diagnosis?
- How has your approach to diagnosing cellulitis changed after managing previous cases?
- If the patient has had previous cellulitis, does this influence your diagnosis?
- From your experience, what differential diagnoses do you think about?
- How do you distinguish cellulitis from these differential diagnoses?
- Specifically, how do you differentiate cellulitis from lymphoedema?
- Specifically, how do you differentiate cellulitis from venous eczema?
- Specifically, how do you differentiate cellulitis from infected venous eczema?
- Specifically, how do you differentiate cellulitis from lymphodermatosclerosis?
- Do you feel that a list of key diagnostic features of cellulitis would help when assessing patients?

We want your views on some aspects of diagnosis that patients with recurrent cellulitis and lymphoedema have discussed

- Patients felt that they were confident in making a self-diagnosis of cellulitis and valued greater trust in self-management at home with treatment. What are your thoughts on patients self-diagnosing?
- Would a photograph with a proforma taken and filled in by the patient and sent to you be helpful in managing patients with recurrent cellulitis?
- In the instance where you may not agree with the patients self-diagnosis of cellulitis, how would you manage the diagnosis?
- Do you feel that any further training or resources should be set up to help improve our diagnosis of cellulitis? For example as specialist cellulitis clinic to refer patients to?
- What are your thoughts on health care professionals having a guide such as checklist to help diagnosis?
- Do you think patients should have this checklist? If so why or why not?

Themes	Sub-themes	Participant quotes
The patient presentation	Confidence in diagnosis	'*I would say it is just experience [helping diagnosis], a lot of the juniors that come into A&E have not seen that many cellulitis [cases]*' (P19, emergency care consultant) '*I probably thought more presentations were [cellulitis] as a junior doctor… I probably didn't really recognise that sort of stretched skin appearance.. I think that has come along as part of just experience over the years, so I probably diagnosed more cellulitis inappropriately as a more junior doctor*' (P13, GP out of hours)
	Cases of misdiagnoses	'*One of the nurse practitioners had seen ankle swelling and the patient thought it… he played some cricket two or three days ago and after one or two days the swelling appeared and she thought that it was just a sprain but next day he represented, I saw him and it looked more like cellulitis because it was quite red, localised area… on close examination I could see a couple of scratches around the ankle so that was maybe the source of cellulitis spreading on the leg*' (P8, emergency care consultant) *'We did see [patients] coming in with "oh this must be a resistant cellulitis", have got a swollen limb that might be a little bit red and it turns out to be some horrible form of lymphoma. You maybe get one or two of those every year where the assumption is that this must be cellulitis because they are really sick and it's a bit red and those can be quite difficult to tease out sometimes, simply because they are sick and the assumption is that it is an infection'* (P2, infectious disease consultant)

		'*Generally anything that is red and hot and on the legs is treated with antibiotics'* (P1, GP) '*There are too many chronic rashes that get referred [to dermatology] as cellulitis*' (P18, dermatology trainee)
	Differential diagnoses	'*One thing that is always a problem in leg swelling…it is difficult to ascertain between DVT and cellulitis*' (P8, emergency care consultant)
Challenges leading to diagnostic uncertainty	Continuum of clinical features	'*Usually the patient is already admitted ….. [the referring team] have tried [multiple antibiotics], but nothing is happening, "please can you come and tell us what is going on?*" (P9, dermatology consultant) '*There are varying ranges of erythema, from a little bit of light pinkness to rip roaring hot red, tender, well demarcated, unilateral; the classic sort of textbook stuff*' (P18, dermatology trainee) ' *I learnt to appreciate much more that [cellulitis] is coming up, it is happening and that it is fading away. A lot of what happened when I was [junior], I was seeing [cellulitis] at the beginning and middle stages, trying to diagnose it, but in dermatology you're seeing it more at that other end of the spectrum..so I think there is a lot [to be] learnt about seeing that pattern developing and progressing and then resolving* ' (P18, dermatology trainee) '*Virtually every patient that I see...they have had their d-dimer and their duplex done so [DVT] is usually a diagnosis that has been excluded*' (P20, dermatology consultant)
	A subjective diagnosis	*'I think the fact that there is no specific diagnostic test… and two*

		different people can look at [possible cellulitis] and come up with two different answers' (P1, GP)
	Community challenges	'*You've not met the patient before and sometimes you're not going to be able to follow them up so you probably are more likely to give antibiotics*' (P12, GP locum) '*If you know the patient and you know that they have recurrent cellulitis, someone had seen it like a district nurse and it is Friday afternoon and you can't get out [for a visit].. you would make a judgement call*' (P1, GP)
	The role of 'defensive' medicine	'*I think you would want to rule out DVT first because if you miss that then that is… a problem*' (P1,GP; P16,surgical trainee) '*We're so much more aware of things like sepsis… looking at any kind of signs of infection*' (P10, district nurse) '*We're all risk adverse aren't we? We would rather make sure we weren't sued because we had missed someone with an infection*' (P2, infectious disease consultant)
	Patient specific factors	' *One of these classical patients that comes in hasn't got a rash and hasn't necessarily got the features that I said of swelling, redness, rash and pain in the leg but they come in none specifically unwell and they may have described a bit of an ache in the leg or something like that but there is nothing else to go on examining the patient for signs, so I think those patients are much trickier'* (P5, acute medicine consultant) *'People with chronic red [legs], their legs are red most of the time.. the skin takes so long to settle, so they could have had cellulitis four weeks ago and it is*

		still red' (P17, advanced nurse practitioner)
Strategies to improve diagnosis	Using time as a guide	'*All you can really do is reassure the patient and say…I don't see any clear evidence of cellulitis but we will keep an eye on it…. you give safety net advice to the patients'* (P18, dermatology trainee) '*So if they were well.. then I would bring them back to clinic the next day or two*' (P4, acute medicine consultant)
	Trial of treatment	'*Cellulitis…was the easiest thing to try and treat so I think that definitely pushed [me] to try some antibiotics and see if this is an infection*' (P11, GP trainee) '[*My concerns with this approach] are antibiotic resistance and side effects…especially in older groups..I would say probably that is not the best approach'* (P3, GP)
	Biochemical investigations	'*If I am thinking about doing blood tests…it is unlikely that I am going to continue managing them in the community*' (P11, GP trainee) '*[With cellulitis]….you expect a) it is unilateral, b) you want some inflammatory markers which are raised, at least a reasonable WCC and CRP and if it is normal it is not going to be cellulitis'* (P9, dermatology consultant) '*I would never not diagnose somebody [with cellulitis] just because their inflammatory markers are normal*' (P5, acute medicine consultant)
	Further education	*'You very quickly just get entrenched in…your preferences for diagnoses and it is often good to refresh*' (P11, GP trainee) '*I only did two weeks [of dermatology] as a medical student… but certainly increasing dermatology teaching at an earlier stage would make a massive difference'* (P13, GP).

		'*It is all very well seeing pictures but pictures aren't that helpful sometimes, it is how it feels sometimes that makes a difference and actually seeing it in the flesh is very different to seeing even good quality pictures, so I do think that clinical exposure [is important]*' (P13, GP). '*It is not something people will have put a lot of thought into, the differentials, and I think the focus needs to be on teaching the frontline staff*' (P15, dermatology consultant). '*Pattern recognition and [seeing] variation in the progression of the rash [are important]*', thereby appreciating the '*life of rashes*' (P18, dermatology trainee).
The need for an objective diagnostic aid	A diagnostic algorithm	'*I think it can be helpful to have those objective measures [of an algorithm], if it was accepted and validated as a reasonable measure of cellulitis, I think I would actually use that*' (P11, GP trainee). *'[A checklist] could help people that weren't experienced or confident enough. To have a checklist as a learning tool is fabulous, it just gives you something to think about like "oh I hadn't thought about the smell, I hadn't thought about the heat"….and I use checklists all of the time'* (P14, dermatology nurse). '*For a diagnostic checklist you almost want it to be provided as an education tool with photographs and descriptions…. so that people can put these differential diagnoses into their head*' (P15, dermatology consultant). '*You would have to develop a criteria that can pick up the beginning, it is in the middle and it*

		is resolving at the end' (P18, dermatology trainee). '*Because there is such a wide differential…how would you exclude all of those and also it can be quite nonspecific sometimes in the early stages*' (P12, GP locum). '*Sometimes the trouble with guidelines, algorithms.… you could probably cover 95% but does it mean that actually the atypical 5% then [do not] get diagnosed?*' (P20, dermatology consultant).

Standards for Reporting Qualitative Research (SRQR)*

http://www.equator-network.org/reporting-guidelines/srqr/

	Page/line no(s).
Title and abstract	
Title - Concise description of the nature and topic of the study Identifying the study as qualitative or indicating the approach (e.g., ethnography, grounded theory) or data collection methods (e.g., interview, focus group) is recommended	Page 1/line 1-2
Abstract - Summary of key elements of the study using the abstract format of the intended publication; typically includes background, purpose, methods, results, and conclusions	Page 2/lines 43-67
Introduction	
Problem formulation - Description and significance of the problem/phenomenon studied; review of relevant theory and empirical work; problem statement	Page 4/ lines 91-101
Purpose or research question - Purpose of the study and specific objectives or questions	Page 4/lines 100-101
Methods	
Qualitative approach and research paradigm - Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., postpositivist, constructivist/ interpretivist) is also recommended; rationale**	Page 7/lines 163-168
Researcher characteristics and reflexivity - Researchers' characteristics that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, and/or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, and/or transferability	Page 6/ lines 139-145
Context - Setting/site and salient contextual factors; rationale**	Page 6/lines 147-149
Sampling strategy - How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling saturation); rationale**	Pages 5-6/ lines 122-135
Ethical issues pertaining to human subjects - Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues	Page 5/ lines 112-116
Data collection methods - Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources/methods, and modification of procedures in response to evolving study findings; rationale**	Page 6-7/ lines 151-158

Data collection instruments and technologies - Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study	Pages 6-7/ lines 151-158
Units of study - Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)	In the results, Page 8/lines 180-181 and Table 1
Data processing - Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and anonymization/de-identification of excerpts	Page 6/ lines 159-161
Data analysis - Process by which inferences, themes, etc., were identified and developed, including the researchers involved in data analysis; usually references a specific paradigm or approach; rationale**	Page 7/lines 162-174
Techniques to enhance trustworthiness - Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationale**	Page 7/ lines 165-174

Results/findings

Synthesis and interpretation - Main findings (e.g., interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory	Pages 8-17/ lines 179-329
Links to empirical data - Evidence (e.g., quotes, field notes, text excerpts, photographs) to substantiate analytic findings	Pages 8-17/ lines 179-329

Discussion

Integration with prior work, implications, transferability, and contribution(s) to the field - Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application/generalizability; identification of unique contribution(s) to scholarship in a discipline or field	Page 18/lines 348-369, Pages 19-21/391-418
Limitations - Trustworthiness and limitations of findings	Page 19/ lines 370-390

Other

Conflicts of interest - Potential sources of influence or perceived influence on study conduct and conclusions; how these were managed	Page 21/line 433-434
Funding – Sources of funding and other support; role of funders in data collection, interpretation, and reporting	Page 1/ lines 22-23

*The authors created the SRQR by searching the literature to identify guidelines, reporting standards, and critical appraisal criteria for qualitative research; reviewing the reference lists of retrieved sources; and contacting experts to gain feedback. The SRQR aims to improve the transparency of all aspects of qualitative research by providing clear standards for reporting qualitative research.

**The rationale should briefly discuss the justification for choosing that theory, approach, method, or technique rather than other options available, the assumptions and limitations implicit in those choices, and how those choices influence study conclusions and transferability. As appropriate, the rationale for several items might be discussed together.

Reference:

O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. **Standards for reporting qualitative research: a synthesis of recommendations.** *Academic Medicine*, Vol. 89, No. 9 / Sept 2014
DOI: 10.1097/ACM.0000000000000388

BMJ Open

An interview study to determine the experiences of cellulitis diagnosis amongst health care professionals in the UK.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-034692.R2
Article Type:	Original research
Date Submitted by the Author:	21-Jul-2020
Complete List of Authors:	Patel, Mitesh; University of Nottingham, ; Lee, Siang Ing; University of Nottingham, Nottingham, UK, Division of Primary Care & National Institute for Health Research, School of Medicine, Levell, Nick; Norfolk and Norwich University Hospital NHS Foundation Trust, Dermatology Smart, Peter; University of Nottingham, Nottingham, UK Kai, Joe; University of Nottingham, Nottingham, UK Thomas, Kim; University of Nottingham, Centre of Evidence Based Dermatology Leighton, Paul; University of Nottingham, Centre of Evidence Based Dermatology
Primary Subject Heading:	Dermatology
Secondary Subject Heading:	Infectious diseases, Qualitative research
Keywords:	DERMATOLOGY, Adult dermatology < DERMATOLOGY, Infectious diseases & infestations < DERMATOLOGY, QUALITATIVE RESEARCH

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Title: An interview study to determine the experiences of cellulitis diagnosis amongst health care professionals in the UK.

Running head: Cellulitis diagnosis by health care professionals

Word count: 3981

Table count: 4

Figure count: 1

Supplementary material: 1

Authors: M Patel, [1,2] S I Lee, [1] NJ Levell, [3] P Smart, [4] J Kai, [1] KS Thomas, [2] P Leighton, [2]

[1] Division of Primary Care & National Institute for Health Research, School of Medicine, University of Nottingham, Nottingham, UK

[2] Centre of Evidence Based Dermatology, University of Nottingham, Nottingham, UK

[3] Dermatology Department, Norfolk and Norwich University Hospital NHS Trust, UK

[4] Patient representative, Centre of Evidence Based Dermatology, University of Nottingham, Nottingham, UK

ORCID ID: M Patel (0000-0003-3975-4689), SI Lee (0000-0002-2332-5452), NJ Levell (0000-0003-3393-8305), J Kai (0000-0001-9040-9384), KS Thomas (0000-0001-7785-7465), P Leighton (0000-0001-5208-0274),

Corresponding author: Mitesh Patel, Division of Primary Care, School of Medicine, University of Nottingham, Nottingham, UK, Email: mpatel59@doctors.org.uk

Funding sources: This study was supported by the Scientific Foundation Board of the Royal College of General Practitioners (grant SFB 2018 – 31).

Study registration: Centre of Evidence Based Dermatology website - https://www.nottingham.ac.uk/research/groups/cebd/documents/researchdocs/protocol-diagnosing-lower-limb-cellulitis-health-care-professionals.pdf

Data sharing: No additional data available

Abstract

Objectives: To explore health care professionals (HCPs) experiences and challenges in diagnosing suspected lower limb cellulitis.

Setting: UK nationwide.

Participants: 20 qualified HCPs, who had a minimum of two years clinical experience as a HCP in the national health service and had managed a clinical case of suspected cellulitis of the lower limb in the UK. HCPs were recruited from departments of dermatology (including a specialist cellulitis clinic), general practice, tissue viability, lymphoedema services, general surgery, emergency care and acute medicine. Purposive sampling was employed to ensure that participants included consultant doctors, trainee doctors and nurses across the specialties listed above. Participants were recruited through: national networks,

HCPs who contributed to the cellulitis priority setting partnership (PSP), UK Dermatology Clinical Trials Network, snowball sampling where participants helped recruit other participants, personal networks of the authors.

Primary and secondary outcomes: Primary outcome was to describe the key clinical features which inform the diagnosis of lower limb cellulitis. Secondary outcome was to explore the difficulties in making a diagnosis of lower limb cellulitis.

Results: The presentation of lower limb cellulitis changes as the episode runs its course. Therefore, different specialties see clinical features at varying stages of cellulitis. Clinical experience is essential to being confident in making a diagnosis, but even amongst experienced HCPs, there were differences in the clinical rationale of diagnosis. A group of core clinical features were suggested, many of which overlapped with alternative diagnoses. This emphasises how the diagnosis is challenging, with objective aids and a greater understanding of the mimics of cellulitis required.

Conclusion: Cellulitis is a complex diagnosis and has a variable clinical presentation at different stages. Although cellulitis is a common diagnosis to make, HCPs need to be mindful of alternative diagnoses.

Keywords: lower limb, cellulitis, diagnosis, health care professionals

Article summary

Strengths and limitations of this study

- The research question was developed from research priorities in the cellulitis priority setting partnership, involving patients.
- Participants were included nationally around the UK.
- Participants from various specialities that commonly diagnose cellulitis were recruited.
- Our recruitment strategy is most likely to have targeted health care professionals with an interest in dermatology.
- The size and scope of the sample population is a limitation.

Introduction

Cellulitis is a frequent presentation in both the community and secondary care, with 60% of presentations affecting the lower limbs.[1] However, the diagnosis of cellulitis can be challenging, with up to a third of suspected lower limb cellulitis cases being later diagnosed as other diagnoses.[2] This results in avoidable hospital admissions and unnecessary antibiotic prescribing [3] and is further compounded by the lack of validated diagnostic criteria or tools for cellulitis.[4]

A UK cellulitis research priority setting partnership (PSP) determined that improving health care professionals' (HCPs) diagnostic accuracy is a key priority for future cellulitis research.[5] An interview study of people with recurrent cellulitis and lymphoedema suggested that patients often experience difficulties in obtaining a speedy and accurate diagnosis. [6]

The aims of this interview study were to explore the HCP experiences and challenges faced in diagnosing suspected lower limb cellulitis.

Methods

Protocol registration and Ethics

The final protocol was registered on the Centre of Evidence Based Dermatology (CEBD) website (9 May 2019). Ethical approval was granted by the Health Research Authority and Health and Care Research Wales (19/HRA/0485) (30 November 2018). Verbal and written consent was obtained from each participant.

Patient and public involvement

The research question was developed from research priorities in the cellulitis PSP, involving patients. A patient representative helped design this study and is a co-author. On publication, participants will be sent the final manuscript.

Eligibility criteria

Selection of participants

Participants were qualified HCPs, who had a minimum of two years clinical experience as a HCP in the national health service (NHS) and had managed a clinical case of suspected cellulitis of the lower limb in the UK. Two years' experience was the minimum requirement as then HCP's will have gained adequate exposure to cellulitis cases. HCPs were recruited from departments of dermatology (including a specialist cellulitis clinic), general practice, tissue viability, lymphoedema services, general surgery, emergency care and acute medicine.

Purposive sampling was employed to ensure that participants included consultant doctors, trainee doctors and nurses across the specialties listed above. Participants were recruited through:

- National networks
- HCPs who contributed to the cellulitis PSP
- UK Dermatology Clinical Trials Network
- Snowball sampling where participants helped recruit other participants
- Personal networks of the authors

Potential participants were approached and recruited by email. Data collection and analysis were undertaken concurrently and sampling ceased when thematic saturation had been achieved (i.e. new interviews generated no new insights).[7]

Researcher characteristics

Interviews were conducted by MP (male), and coded and analysed by MP and SIL (female) (both general practitioner (GP) trainees who had managed clinical cases of cellulitis previously). Both MP and SIL attended qualitative methodology training courses. The broader research group included experienced clinical-academics (JK (academic GP) and NL (clinical professor of

dermatology), a patient representative (PS) and senior qualitative experts (JK and PL). Three participants had clinical interactions with the interviewer in the past, but not regarding cellulitis.

Interview setting

Each participant took part in a single, semi-structured, qualitative interview. Two interviews were face to face, with the remaining via telephone. Written consent was gained from participants, with additional verbal consent gained before the interview. All participants received a £20 reimbursement voucher or donated this fee to the British Skin Foundation charity.

Data collection

Prior to the interview, participants were asked to reflect upon their most recent experiences of making a cellulitis diagnosis, focusing on the typical presentations, challenging cases and differential diagnoses.

A topic guide, informed by a prior systematic review and interview study,[8] was used to structure the interview (Supplementary material). However, participants were urged to propose and/or expand on topics which they felt were relevant to their experience of diagnosis. New topics were then added to the topic guide for subsequent interviews.

Data processing

Interviews were audio-recorded and transcribed. Transcripts were checked (by MP) and data managed using QSR NVivo 12 software.

Data analysis

Analysis was inductive, searching for themes in the data. A structured, systematic, multi-stage approach to thematic analysis was followed.[9] Coders immersed themselves in the data, by reading the data set before coding. Data were coded manually by MP, with SIL also independently coding a third of the transcripts. A list of each code, with a brief description was then used to group the codes into theme-piles. Themes were defined and refined, with sub-themes also developed.

Uncertainties in coding and thematic organisation were resolved in discussion with the other authors. Data collection and analysis was concurrent. The final codebook was agreed by all authors and is presented in Figure 1. The interviewer kept a reflexive research diary, logging intuitive thoughts and immediate reflections after each interview. These reflections, as well as queries around data collection, handling and interpretation were then discussed at regular research meetings.

Results

Twenty HCPs were interviewed (Table 1). Interviews were conducted between 19 March and 11 June 2019, with a mean duration of 29 minutes.

Table 1: Characteristics of the participants

Participant	Ethnicity	Clinical role	Number of times they have diagnosed cellulitis	Time since they last diagnosed cellulitis
1	Asian British	GP	>50	One week ago
2	White British	Acute medicine/infectious disease consultant	>50	One week ago
3	White Irish	GP	>50	Three weeks ago
4	White British	Acute medicine consultant	>50	Last four weeks
5	White British	Acute medicine consultant	>50	One week ago

6	White British	Tissue viability nurse	10-50	Less than one week
7	White British	Lymphoedema specialist nurse	>50	One week ago
8	Asian British	Emergency medicine consultant	>50	Less than one week
9	Asian British	Dermatology consultant	10-50	Four weeks ago
10	White British	District nurse	>50	Last three months
11	Black	GP trainee	10-50	Less than one week
12	White British	GP locum	10-50	Two weeks ago
13	White British	GP out of hours	>50	Two weeks ago
14	White British	Dermatology specialist nurse	>50	Last three months
15	White British	Dermatology consultant	10-50	Last 12 months
16	Mixed	Surgical trainee	10-50	Last four weeks
17	White British	Community advanced nurse practitioner	>50	Less than one week
18	White British	Dermatology trainee	>50	Four weeks ago
19	White British	Emergency medicine consultant	>50	Last three months
20	White British	Dermatology consultant	>50	Less than one week

184

Main findings

Four key themes were identified: 1) The patient presentation; 2) Challenges leading to diagnostic uncertainty; 3) Strategies to improve diagnosis; 4) The need for an objective diagnostic aid, with further classification into sub-themes. How the codes mapped onto the overarching themes are shown in Table 2.

Table 2: How the codes mapped onto themes

Themes	Sub-themes	Codes
The patient presentation	The typical patient and risk factors	• Typical cellulitis presentations
		• Factors that increase the likelihood of cellulitis diagnosis
	Confidence in diagnosis	• Most suitable HCP to diagnose cellulitis •
		• Experience guides diagnosis
	Cases of misdiagnoses	• Missed/delayed diagnosis of cellulitis (final diagnosis)
		• Missed/delayed diagnosis of cellulitis (initial diagnosis)
	Differential diagnoses	• List of alternative diagnosis
Challenges leading to diagnostic uncertainty	Continuum of clinical features	• Changes in clinical presentation
	A subjective diagnosis	• Reasons why cellulitis diagnosis is challenging
	Community challenges	• Seeing patients part way through assessment and management
		• Follow up of patients
	The role of 'defensive' medicine	• Sepsis as a concern
		• Medico legal issues as a factor
		• Fear of missing more serious differentials
	Patient specific factors	• Other factors influencing diagnosis
Strategies to improve diagnosis	Using time as a guide	• Time and safety netting approach
		•
	Trial of treatment	• Trial of treatment guides diagnosis

		•
	Biochemical investigations	• Investigations to aid diagnosis
	Seeking advice	• Discussing diagnosis with colleagues
	Further education	• Suggestions on what may improve diagnosis
The need for an objective diagnostic aid	A diagnostic algorithm	• Views on diagnostic aids for HCP
	Indices for an algorithm	• Clinical features to include in diagnostic algorithm

Diagnosis of cellulitis

The typical patient and risk factors

In general practice, the typical patient described by participants included older adults with co-morbidities; concerns of possible cellulitis cases were often raised by district nursing colleagues. Emergency care and acute services described people who presented with features of systemic compromise. Both infectious disease and general surgery services often managed intravenous drug users who were at risk of deeper infection.

Factors that HCPs stated increased the likelihood of cellulitis were: features of systemic upset including fever, malaise, rigors; co-existing injury or infection such as tinea, superficial ulceration, previous history of cellulitis, previous history of dermatological conditions such as

eczema, diabetes, immunosuppressive medications and those with no fixed abode with social and health risks. Bilateral symptoms were commonly described by participants as a factor increasing the likelihood of chronic, systemic pathologies rather than cellulitis.

Confidence in diagnosis

One dermatologist explained how being more aware of the differential diagnoses made them more likely to accurately diagnose cellulitis, especially compared to junior colleagues. Generally, HCPs with more clinical experience felt more confident with diagnosis, as they appreciated the presentation with more observed cases '*I would say it is just experience [helping diagnosis], a lot of the juniors that come into A&E have not seen that many cellulitis [cases]* (P19, emergency care consultant, 10 years clinical experience).

A dermatology trainee felt seeing less cellulitis cases during their training compared to their senior colleagues historically, and therefore not getting as much exposure, hindered accurate diagnosis.

Cases of misdiagnoses

Trauma related skin changes was frequently an initial misdiagnosis in the emergency department. When discussing cases of uncertainty, where cellulitis was the initial suspected diagnosis, one GP described a case of venous eczema which was managed with repeated antibiotics '*Generally anything that is red and hot on the legs is treated with antibiotics'* (P1, GP, >13 years clinical experience). Chronic rashes were frequently seen by dermatology and infectious disease discussed lymphoma cases initially referred as cellulitis *'We did see [patients] coming in with "Oh this must be a resistant cellulitis", have got a swollen limb that might be a little bit red and it turns out to be some horrible form of lymphoma'* (P2, infectious disease consultant, 25 years clinical experience).

The importance of a correct diagnosis is key, as two participants discussed the possibility of prophylactic antibiotics for patients with recurrent cellulitis. A dermatology consultant explained how misdiagnosis can result in inappropriate and costly admissions to the ward.

Differential diagnoses

A frequent diagnosis of uncertainty for primary and emergency care was deep vein thrombosis (DVT), as the clinical features of cellulitis can overlap *'One thing that is always a problem is leg swelling…it is difficult to ascertain between DVT and cellulitis'* (P8, emergency care consultant,

20 years clinical experience). Common differential diagnoses discussed by participants, which they observed in their clinical practice, with discriminating features from cellulitis that they described, are shown in Table 3.

Table 3: Differential diagnoses of lower limb cellulitis discussed by participants

Differential diagnoses	Key differentiating factors from cellulitis
Chronic heart failure causing oedema	Chronic, bilateral, lack of mobility, breathless, cardiac history (P1,GP;P14,dermatology specialist nurse)
Venous eczema	Usually chronic with hemosiderin scaling, itching, crusting, likely bilateral, possibly eczema elsewhere on body, less well defined, (P3,GP;P15, dermatology consultant)
Thrombophlebitis	Tender, localised, hard, lumpy rash around an often-thickened vein (P3,GP;P5,acute medicine consultant;P12,GP locum)
Erythema nodosum	Multiple, discrete swellings (P13,GP out of hours)
Deep vein thrombosis	Pain is usually deep in calf rather than superficial, less sharply demarcated and less intense erythema, diffuse swelling of limb, can be young, can be intravenous drug users, high DVT wells score, fewer systemic features (P2,infectious disease consultant;P12,GP locum;P13,GP out of hours)

Lymphoedema	Chronic, bilateral, usually less painful, thickened warty skin in the long-term, normal inflammatory markers (P9,dermatology consultant;P18,dermatology trainee)
Allergic reaction to insect bites	Central puncture mark, itch, when acute, developing lichenified erythema when chronic (P2,infectious disease consultant)
Lipodermatosclerosis	Often bilateral, systemically well, tight non tender skin with inverted champagne bottle appearance (P4,acute medicine consultant; P20,dermatology consultant)
Necrotising fasciitis	Crepitus, rapidly spreading, septic, very tender (P5,acute medicine consultant; P16, surgical trainee)
Wound infection	Local to the wound, covers small area, yellow exudate, strong odour (P10,district nurse; P16,surgical trainee)
Baker's cyst	Unilateral popliteal swelling, suddenly more tender on rupture (P15,dermatology consultant)

Challenges leading to diagnostic uncertainty

The continuum of clinical features

Participants described how the presentation of lower limb cellulitis changed as the episode ran its course. This was influenced by when patients seek clinical review and meant that different specialties observed clinical features at varying stages of cellulitis.

In dermatology services, presentations were seen later in the episode. However, partial treatment and response did make the diagnosis challenging as the initial typical features of cellulitis may then vary. However, seeing patients later in the journey allowed dermatologists to appreciate the progression of clinical features '*I learnt to appreciate much more that [cellulitis] is coming up, it is happening and that it is fading away… When I was [junior], I was seeing [cellulitis] at the beginning and middle stages, trying to diagnose it, but in dermatology you're seeing it more at that other end of the spectrum...so I think there is a lot [to be] learnt about seeing that pattern developing and progressing and then resolving'* (P18, dermatology trainee, eight years clinical experience)

Importantly for dermatologists, other more serious pathologies such as a DVT had often been ruled out.

A subjective diagnosis

One GP explained how there is no specific test that can aid diagnosis, thus subjective assessment can lead to different diagnoses *'I think the fact that there is no specific diagnostic test… and two different people can look at [possible cellulitis] and come up with two different answers'* (P1, GP, >13 years clinical experience). She added how this is further influenced by previous experiences, including how long and where HCPs have trained

Community challenges

In the community, additional challenges for GPs were not being familiar with the patient's background history, seeing a patient for the first time, or taking over care part way through the patient journey. Working as a locum doctor with a lack of follow up available, often led to treatment when unsure of the diagnosis '*You've not met the patient before and sometimes you're not going to be able to follow them up so you probably are more likely to give antibiotics*' (P12, GP locum, seven years clinical experience). Limited resources to see patients, such as not being able to conduct an urgent home visit, also influenced diagnosis and subsequent management by GPs.

The role of 'defensive' medicine

HCPs in the community, emergency care and surgery were particularly wary of missing a more serious diagnosis, which needed to be ruled out first, such as DVT and necrotising fasciitis (NF) '*I think you would want to rule out DVT first because if you miss that then that is… a problem*' (P1, GP, >13 years clinical experience; P16, female, surgical trainee, five years clinical experience). Many HCPs also mentioned '*sepsis*' when discussing clinical features and diagnosis. This may be leading to an over diagnosis of cellulitis due to concerns of medico legal complaints of missing an infection which could then get worse '*We're all risk adverse aren't we? We would rather make sure we weren't sued because we had missed someone with an infection*' (P2, infectious disease consultant, 25 years clinical experience).

Patient specific factors

Participants found people with pigmented skin, lymphoedema and with nonspecific symptoms particularly difficult to diagnose in the acute setting '*One of these classical patients that comes in hasn't got a rash ... [or] the features of swelling, redness, rash and pain in the leg but they come in none specifically unwell ... I think those patients are much trickier [to diagnose cellulitis]*' (P5, acute medicine consultant, 16 years clinical experience). One nurse described another

diagnostic challenge was when a patient presents with chronic skin changes or a recent episode of cellulitis with continuing signs '*People with chronic red [legs], their legs are red most of the time... the skin takes so long to settle, so they could have had cellulitis four weeks ago and it is still red'* (P17, advanced nurse practitioner, 20 years clinical experience).

Strategies used to reduce uncertainty

Using time as a guide

In cases where the HCP was not sure of the diagnosis, different strategies were employed. Using time to allow further clinical features to develop, with appropriate safety netting was a commonly used approach. This was easier when follow-up appointments were available in the community, but was also done in the acute setting '*So if they were well... then I would bring them back to clinic the next day or two*' (P4, acute medicine consultant, 17 years clinical experience). But follow-up in secondary care was difficult, often not done and can be a missed opportunity to learn from incorrect diagnoses previously.

Trial of treatment

Some HCPs started antibiotics for a suspected cellulitis and reviewed the response to help provide the diagnosis retrospectively '*Cellulitis…was the easiest thing to try and treat so I think that definitely pushed [me] to try some antibiotics and see if this is an infection*' (P11, GP

trainee, six years clinical experience). A major concern highlighted by one GP with this approach was antibiotic resistance and side effects. However, overall, there was a common understanding in primary care why this approach was taken in some instances.

Biochemical investigations

In primary care, one doctor described how blood tests and cultures were rarely done to diagnose cellulitis, as such patients would need to be seen in secondary care. Blood cultures were requested by the infectious disease physician if it was an atypical infection, but a challenge described by one dermatology consultant was that organisms are not isolated in the majority of patients. Swabs were done for discharging wound infections, mainly by district nurses or prior to discussion with microbiology, when see by dermatologists.

An emergency physician and surgical trainee explained how blood tests and imaging such as x-rays are important to check for osteomyelitis. The blood tests commonly requested by secondary care HCPs were white cell count (WCC) and C-reactive protein (CRP) for infection with one dermatologist stating how changes in blood test results were important when taking referrals for suspected cellulitis '*[With cellulitis]...you expect a) it is unilateral, b) you want some inflammatory markers which are raised, at least a reasonable WCC and CRP and if it is normal*

it is not going to be cellulitis' (P9, dermatology consultant, 10 years clinical experience). However, one challenge with interpreting blood tests was in the group partially treated with antibiotics, who have improving blood tests but limited clinical response. A biomarker or point of care test for cellulitis were suggested as investigations to aid diagnosis by one dermatology consultant and one GP respectively.

Seeking advice

Another approach during uncertainty was to discuss with colleagues. In the community the nurse may ask the GP to review and vice versa. In hospital, specialists in infectious disease, dermatology, microbiology and general/plastic surgeons are most often contacted for review.

Further education

Many HCPs mentioned teaching sessions to improve diagnosis, both at the undergraduate and postgraduate level. One GP stated that real life clinical cases were felt to be important for teaching, rather than focusing on pictures '*It is all very well seeing pictures but pictures aren't that helpful sometimes, it is how it feels sometimes that makes a difference and actually seeing it in the flesh is very different to seeing even good quality pictures, so I do think that clinical exposure [is important]* (P13, GP, 20 years clinical experience).

A dermatology consultant suggested that a key area of education amongst HCPs was being aware of differential diagnoses for frontline services '*It is not something people will have put a lot of thought into, the differentials, and I think the focus needs to be on teaching the frontline staff* (P15, dermatology consultant, 18 years clinical experience).

One trainee who worked in a specialist cellulitis clinic found that seeing many cases helped improve her recognition of cellulitis.

The need for an objective diagnostic aid

A diagnostic algorithm

Many participants mentioned developing a diagnostic algorithm, similar to the Wells score for DVT. A GP explained how this may also help GPs make a validated clinical decision when colleagues such as district nurses are suspecting cellulitis and the patient cannot be seen quickly. A dermatology nurse described how she often used checklists and how an algorithm would help HCP's not to miss any clinical features *'[A checklist] could help people that weren't experienced or confident enough…it just gives you something to think about like "oh I hadn't thought about the heat'"* (P14, dermatology nurse, nine years clinical experience).

One dermatology consultant suggested that a diagnostic checklist should be more of an educational tool to help rule out other differential diagnoses '*For a diagnostic checklist you almost want it to be provided as an education tool with photographs and descriptions... so that people can put these differential diagnoses into their head* (P15, dermatology consultant, 18 years clinical experience).

A dermatology trainee felt that the indices of a checklist would have to reflect how cellulitis changes through the course of the episode. Other challenges described by participants, regarding developing an algorithm were the number of alternative diagnoses, with features that often overlapped with cellulitis and vague initial features. Another concern highlighted by a dermatology consultant was that algorithms will miss patients who may present with atypical features '*Sometimes the trouble with guidelines, algorithms... you could probably cover 95% but does it mean that actually the atypical 5% then [do not] get diagnosed?* (P20, dermatology consultant, 42 years clinical experience).

Indices for an algorithm

The key clinical features HCPs suggested to include in a diagnostic algorithm for lower limb cellulitis were: unilateral, pain, erythema, warmth of limb, pyrexia, swelling, acute onset, trauma

to the limb, break in the skin, single area affected, clear demarcation, exudate, flu like malaise, tracking rash, shiny, tenser skin, previous cellulitis, co-existing immunosuppression, co-existing skin conditions, clinical observations for sepsis, negative Wells score and patient concern. No HCP suggested blood tests were a priority in the algorithm, but a GP trainee suggested it could be included in a modified algorithm in secondary care, similar to the CURB-65 score used for pneumonia.

Additional quotes from participants are shown in Table 4.

Table 4: Additional quotes from participants, grouped into themes and subthemes

Themes	Subthemes	Participant quotes
The patient presentation	**Confidence in diagnosis**	'*I probably thought more presentations were [cellulitis] as a junior doctor… I probably didn't really recognise that sort of stretched skin appearance.. I think that has come along as part of just experience over the years, so I probably diagnosed more cellulitis inappropriately as a more junior doctor*' (P13, GP out of hours, 20 years clinical experience)
	Cases of misdiagnoses	'O*ne of the nurse practitioners had seen ankle swelling and the patient thought it… he played some cricket two or three days ago and after one or two days the swelling appeared and she thought that it was just a sprain but next day he represented, I saw him and it looked more like cellulitis because it was quite red, localised area… on close examination I could see a couple of scratches around the ankle so that was maybe the source of cellulitis spreading on the leg'* (P8, emergency care consultant, 20 years clinical experience)

		'*There are too many chronic rashes that get referred [to dermatology] as cellulitis*' (P18, dermatology trainee, eight years clinical experience)
Challenges leading to diagnostic uncertainty	**Continuum of clinical features**	'*Usually the patient is already admitted ... [the referring team] have tried [multiple antibiotics], but nothing is happening, "please can you come and tell us what is going on?"*' (P9, dermatology consultant, 10 years clinical experience) '*There are varying ranges of erythema, from a little bit of light pinkness to rip roaring hot red, tender, well demarcated, unilateral; the classic sort of textbook stuff* (P18, dermatology trainee, eight years clinical experience) '*Virtually every patient that I see...they have had their d-dimer and their duplex done so [DVT] is usually a diagnosis that has been excluded* (P20, dermatology consultant, 42 years clinical experience)
	Community challenges	'*If you know the patient and you know that they have recurrent cellulitis, someone had seen it like a district nurse and it is Friday afternoon and you can't get out [for a visit].. you would make a judgement call* (P1, GP, >13 years clinical experience)
	The role of 'defensive' medicine	'*We're so much more aware of things like sepsis… looking at any kind of signs of infection*' (P10, district nurse, 25 years clinical experience)
Strategies to improve diagnosis	**Using time as a guide**	'*All you can really do is reassure the patient and say…I don't see any clear evidence of cellulitis but we will keep an eye on it... you give safety net advice to the patients'* (P18, dermatology trainee, eight years clinical experience)
	Trial of treatment	'[*My concerns with this approach] are antibiotic resistance and side effects…especially in older groups...I would say probably that is not the best approach'* (P3, GP, 18 years clinical experience)
	Biochemical investigations	'*If I am thinking about doing blood tests…it is unlikely that I am going to continue managing them in the community*' (P11, GP trainee, six years clinical experience)

		'*I would never not diagnose somebody [with cellulitis] just because their inflammatory markers are normal* (P5, acute medicine consultant, 16 years clinical experience)
	Further education	*'You very quickly just get entrenched in…your preferences for diagnoses and it is often good to refresh*' (P11, GP trainee, six years clinical experience) '*I only did two weeks [of dermatology] as a medical student… but certainly increasing dermatology teaching at an earlier stage would make a massive difference'* (P13, GP, 20 years clinical experience). '*Pattern recognition and [seeing] variation in the progression of the rash [are important]*', thereby appreciating the '*life of rashes*' (P18, dermatology trainee, eight years clinical experience).
The need for an objective diagnostic aid	**A diagnostic algorithm**	'*I think it can be helpful to have those objective measures [of an algorithm], if it was accepted and validated as a reasonable measure of cellulitis, I think I would actually use that*' (P11, GP trainee, six years clinical experience). '*You would have to develop a criteria that can pick up the beginning, it is in the middle and it is resolving at the end*' (P18, dermatology trainee, eight years clinical experience). '*Because there is such a wide differential…how would you exclude all of those and also it can be quite nonspecific sometimes in the early stages*' (P12, GP locum, 7 years clinical experience).

Discussion

Summary

This study found that the presentation of lower limb cellulitis changes as the episode progresses, leading to variation in the clinical features, seen in different clinical settings. This may be reflected in the range of typical differential diagnoses that specialities discussed and has been described in literature.[10]

Clinical experience was described as an important factor in making a more accurate diagnosis. Dermatologists have previously been suggested as the ideal HCP to diagnose cellulitis.[11] However, the clinical reasoning behind a diagnosis were contradictory between some HCPs.

A core group of clinical features to diagnose cellulitis were suggested. But the challenge is that these features can overlap with other pathologies, irrespective of how likely these are.[12] More serious pathologies then need to be ruled out first, both for the safety of the patient and to avoid medico-legal consequences.

Suggestions to improve the accuracy of diagnoses included developing a diagnostic algorithm which could objectively help HCPs with different levels of experience.[13] The challenge with a diagnostic algorithm is that it would need to incorporate the various stages of a cellulitis episode and therefore various versions of an algorithm might be required.

Importantly, having a greater understanding of the alternative diagnoses is required, especially when the features are vague, atypical or not responding to antibiotic treatment. Educating both doctors and nurses, using real life clinical scenarios and a focus on differential diagnoses, was also discussed and may be an initial feasible approach to improve diagnostic accuracy. A visually based computerized diagnostic decision support system, focusing on differential diagnoses, has been shown to improve the diagnostic accuracy of cellulitis. [14]

Strengths and limitations

A key strength of this study that participants were included nationally around the UK, across various specialities that commonly diagnose cellulitis, with both nurses and doctors of varying clinical experience.

Like similar studies, the size and scope of the sample population is a limitation of this work. Whilst we argue that our findings are transferable to other settings, we acknowledge that those

interviewed were perhaps more interested and better informed about dermatology than many HCPs. This was a function of our purposive sampling, and the likelihood that those interested in cellulitis were more likely to consent to an interview. Furthermore, the participants in this study were mainly female doctors. This may not be representative of the workforce in non-UK countries; therefore the transferability of our findings may be limited.

Some participants were unable to fully describe their clinical rationale behind diagnostic decisions during the interview. This may be because they have developed an intuitive, pattern-recognition, approach in decision-making with experience. Such heuristic diagnostic processes in dermatology are well documented. [15]

As the interviewer was a fellow clinician, interviewees may not have fully shared the details of cases that were misdiagnosed or where diagnoses were delayed due to social desirability bias or fear of litigation. Clinical researcher bias was unavoidable, as the interviewer had clinical insight into cellulitis. However, non-clinicians within the broader authorship group were also involved with coding and analysis of the interviews.

Three participants were known to the interviewer, which can lead to response bias, however the interviewer felt this also allowed an honest, open discussion.

Comparison with existing literature

To our knowledge, this is the first interview study undertaken with health care professionals, discussing their experiences of cellulitis diagnosis. Our findings on the clinical features of cellulitis, differential diagnoses and also the need to be aware of mimics have been described in previous review articles.[10] A previous review also described cases of misdiagnosis and emerging approaches to improve diagnoses, [8,16] which were echoed in this study. The diagnostic challenges of infection in primary care, due to atypical presentations and lack of diagnostic tests has previously been described.[17] Using treatments such as antibiotics as diagnostic aids and discussing with colleagues when uncertain about a diagnosis are common strategies. [18,19] Litigation and fear missing a diagnosis has also been well documented in literature. [20]

Implications for research and practice

This study has highlighted that HCPs need to be aware that cellulitis can present with different features at various stages of the acute episode and need to consider the cellulitis mimics. With

a current shift in health care resulting in trained nurses now managing more acute presentations, [21] upskilling nurses in cellulitis could be part of the solution.

Many HCPs felt confident in making an accurate diagnosis, often guided by experience and intuition, but found it difficult to verbalise the key distinguishing features. This makes it difficult for the clinical experience to be shared amongst other colleagues, especially less experienced or junior HCPs. Acquiring this insight is important to improve diagnostic accuracy, which can prevent avoidable antibiotic prescribing and hospital admissions. To overcome this, further qualitative research is required to identify the clinical reasoning behind the expert process of making a diagnosis, perhaps using clinical cases and pictures. This will form the basis of the proposed solution of focused education and clinical features to be included in a diagnostic aid. The challenge with further education for HCPs is that information needs to be accessible for everyone, whilst information overload can lead to a reduction in the quality of decisions. [22]

Some indices and risk factors for a diagnostic algorithm have been identified in this study and previous studies, [23] as well as key distinguishing features from differential diagnosis, but these need validating with larger studies and an expert consensus setting exercise.

Conclusion

This interview study has shown that cellulitis is a complex diagnosis. Not only does the core features overlap with other diagnoses, the presentation of cellulitis changes as the episode progresses. Although cellulitis is a common diagnosis to make, and whilst further research in developing diagnostic aids needs to be undertaken, simply being aware of the cellulitis mimics may help improve diagnostic accuracy.

Acknowledgements

We would like to thank the participants who were interviewed and the professional transcriber Claire Poxon. We also want to thank the Royal College of General Practitioners for supporting this study. The views expressed in this paper are those of the authors and not necessarily those of the National Health Service, the National Institute for Health Research or the Department of Health.

Competing interest

None declared

Author contributions

M Patel was involved with the design of the study, collection and analysis of data, drafting the manuscript and final approval of the manuscript.

S I Lee was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

NJ Levell was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

P Smart was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

J Kai was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

KS Thomas was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

P Leighton was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

References

1 Lazzarini L, Conti E, Tositti G, et al. Erysipelas and cellulitis: clinical and microbiological spectrum in an Italian tertiary care hospital. *J Infect* 2005; **51**(5):383-9.

2 Weng QY, Raff AB, Cohen JM, et al. Costs and Consequences Associated With Misdiagnosed Lower Extremity Cellulitis. *JAMA Dermatol* 2017; **153**(2):141–146.

3 David CV, Chira S, Eells SJ et al. Diagnostic accuracy in patients admitted to hospitals with cellulitis. *Dermatol Online J* 2011 ; **17**(3):1.

4 Patel M, Lee SI, Akyea RK, et al. A systematic review showing the lack of diagnostic criteria and tools developed for lower limb cellulitis. In print: *Br J Dermatol* 2019.

5 Thomas KS, Brindle R, Chalmers JR, et al. Identifying priority areas for research into the diagnosis, treatment and prevention of cellulitis (erysipelas): results of a James Lind Alliance Priority Setting Partnership. *Br J Dermatol* 2017; **177**:541-543.

6 Patel M, Lee SI, Levell NJ, et a. Confidence of recurrent cellulitis self-diagnosis among people with lymphoedema: a qualitative interview study. *Br J Gen Pract 2020*; 70(691).

7 Guest G, Bunce A, Johnson L. How many interviews are enough? An experiment with data saturation and variability. *Field Methods* 2006; 18(1): 59–82.

8 Patel M, Lee SI, Thomas KS, Kai J. The red leg dilemma: a scoping review of the challenges of diagnosing lower - limb cellulitis. *Br J Dermatol* 2019; **180**: 993-1000.

9 Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol* 2006; **3**: 77-101.

10 Bailey E, Kroshinsky D. Cellulitis: diagnosis and management. *Dermatol Ther 2011*; **24**(2):229-239.

11 Levell NJ, Wingfield CG, Garioch JJ. Severe lower limb cellulitis is best diagnosed by dermatologists and managed with shared care between primary and secondary care. *Br J Dermatol 2011;* **164**(6):1326-8.

12 Raff AB, Kroshinsky D. Cellulitis: A Review. *JAMA 2016;* **316**(3):325-37.

13 Pallin DJ, Bry L, Dwyer RC, et al. Toward an Objective Diagnostic Test for Bacterial Cellulitis. *PLoS One 2016*; **11**(9):e0162947.

14 David CV, Chira S, Eells SJ et al. Diagnostic accuracy in patients admitted to hospitals with cellulitis. *Dermatol Online J* 2011; **17**(3):1.

15 Lowenstein EJ. Dermatology and its unique diagnostic heuristics. *JAMA Dermatol* 2018; **78**(6):1239-1240.

16 Edwards G, Freeman K, Llewelyn MJ, Hayward G. What diagnostic strategies can help differentiate cellulitis from other causes of red legs in primary care? *BMJ 2020*; **368**:m54.

17 McKelvie S. Moore A, Croxson C, et al. Challenges and strategies for general practitioners diagnosing serious infections in older adults: a UK qualitative interview study. *BMC Fam Pract 2019;* **20(**56).

18 Hayward GN, Moore A, Mckelvie S, et al. Antibiotic prescribing for the older adult: beliefs and practices in primary care. *J Antimicrob Chemother 2019*;74(3):791-797.

19 Alam R, Cheraghi-Sohi S, Panagioti M, et al. Managing diagnostic uncertainty in primary care: a systematic critical review. *BMC Fam Pract 2017*;**18**(1):79.

20 Birks Y, Aspinal F, Bloor K. Understanding the drivers of litigation in health services. The Kings Fund 2018. University of York.

21 Imison C, Castle-Clarke S, Watson R. Reshaping the workforce to deliver the care patients needs. Research Report. 2016. Nuffield Trust.

22 Kumar A, Maskara S. Coping up with the Information Overload in the Medical Profession. *J Biosci Med 2015*; **3**(11):214-127.

23 Quirke M, Ayoub F, McCabe A, et al. Risk factors for nonpurulent leg cellulitis: a systematic review and meta-analysis. *Br J Dermatol 2017*;**177**(2):382-394.

Figure 1: Standardised codebook used by two independent coders

Supplementary Material

Topic guide used to structure the interview

Codes used

- Trial of treatment guides diagnosis
- Discussing diagnosis with colleagues
- Time and safety netting approach
- Patients who self-diagnose and treat
- Approach when HCPs do not agree with patient self-diagnosis
- Patients involved with diagnosis with the HCP
- Typical cellulitis presentations
- Clinical features of cellulitis
- Factors that decrease the likelihood of cellulitis diagnosis
- Factors that increase the likelihood of cellulitis diagnosis
- Investigations to aid diagnosis
- Missed/delayed diagnosis of cellulitis (final diagnosis)
- Missed/delayed diagnosis of cellulitis (initial diagnosis)
- Patient finds it difficult to accept it is not cellulitis
- Reasons why cellulitis diagnosis is challenging
- Suggestions on what may improve diagnosis
- Views on diagnostic aids for HCP
- Views on diagnostic aids for patients
- Views on how well HCP make diagnosis
- Experience guides diagnosis
- Seeing patients part way through assessment and management
- Differential diagnoses
- Sepsis as a concern
- Medico legal issues as a factor
- Follow up of patients
- Most suitable HCP to diagnose cellulitis
- Fear of missing more serious differentials
- Clinical features to include in diagnostic algorithm
- Other factors influencing diagnosis

If the participant has a recent case of cellulitis that they can discuss:

Can you tell me about a case of cellulitis that you diagnosed?

Prompts:

- What thoughts go through your head when you are considering a diagnosis of cellulitis?
- What symptoms do you ask about? Local? General?
- What signs do you look for? Local? General?
- Are there any specific signs/symptoms you rely on to help?
- Did you do any tests?
- Did you seek advice from anyone else?
- Were you concerned that this may not be cellulitis?
- If you were concerned, why?
- Was there anything challenging about this case?
- How did you address these challenges?
- How confident were you that this was cellulitis on a 1-10 scale when you first saw the patient?
- Did the patient discuss any self-diagnoses?
- Did any external factors such as time influence your decision?
- Did the patient come back to see you again?
- Would you change your approach if the same case presented again?
- Is this a typical case you see?
- What are the main differential diagnoses you see?

Repeat the above for a maximum two cases that the participants may have for the interview (repeat twice only if the participant has no delayed/incorrect cases below).

If the participant has a case where the diagnosis was delayed or incorrect (can be initially either seen by same health care professional or a colleague, but preferably the same person)

Prompts:

- Did you see the patient on initial presentation or was it a colleague?
- If it was another colleague, what specialty did they work in?
- What symptoms did they present with?
- What signs did they have?
- What was the initial diagnosis? And why?
- Were any tests done?
- Did any external factors influence the decision for the initial diagnosis?
- When did they see you or another colleague again?
- If it was another colleague, what specialty did they work in?
- Did anything change with the signs/symptoms?
- What happened next?
- Do you know what the final diagnosis was?
- What were the reasons for the delay in the diagnosis?
- Why was it difficult to make an accurate diagnosis on first consultation?

We want to establish if it is possible to determine a core group of features that can be used to help diagnose lower limb cellulitis

Prompts:

- What symptoms are you asking about?

- Of these symptoms, which do you think are more suggestive of cellulitis?
- Are there any symptoms that make cellulitis less likely?
- Are there other features in the history which make cellulitis more/less likely? (prompt – other conditions, previous history, drugs, family history)
- What signs are you looking for?
- Of these signs, which do you think are more suggestive of cellulitis?
- Would you request any tests if it was available to you on the same day?
- If so what tests would these be?
- Are there any signs in a 'red leg' that would make cellulitis less likely as the diagnosis?
- Are there any signs in a red leg which would make cellulitis more likely as the diagnosis?
- How has your approach to diagnosing cellulitis changed after managing previous cases?
- If the patient has had previous cellulitis, does this influence your diagnosis?
- From your experience, what differential diagnoses do you think about?
- How do you distinguish cellulitis from these differential diagnoses?
- Specifically, how do you differentiate cellulitis from lymphoedema?
- Specifically, how do you differentiate cellulitis from venous eczema?
- Specifically, how do you differentiate cellulitis from infected venous eczema?
- Specifically, how do you differentiate cellulitis from lymphodermatosclerosis?
- Do you feel that a list of key diagnostic features of cellulitis would help when assessing patients?

We want your views on some aspects of diagnosis that patients with recurrent cellulitis and lymphoedema have discussed

- Patients felt that they were confident in making a self-diagnosis of cellulitis and valued greater trust in self-management at home with treatment. What are your thoughts on patients self-diagnosing?
- Would a photograph with a proforma taken and filled in by the patient and sent to you be helpful in managing patients with recurrent cellulitis?
- In the instance where you may not agree with the patients self-diagnosis of cellulitis, how would you manage the diagnosis?
- Do you feel that any further training or resources should be set up to help improve our diagnosis of cellulitis? For example as specialist cellulitis clinic to refer patients to?
- What are your thoughts on health care professionals having a guide such as checklist to help diagnosis?
- Do you think patients should have this checklist? If so why or why not?

Standards for Reporting Qualitative Research (SRQR)*

http://www.equator-network.org/reporting-guidelines/srqr/

	Page/line no(s).
Title and abstract	
Title - Concise description of the nature and topic of the study Identifying the study as qualitative or indicating the approach (e.g., ethnography, grounded theory) or data collection methods (e.g., interview, focus group) is recommended	Page 1/line 1-2
Abstract - Summary of key elements of the study using the abstract format of the intended publication; typically includes background, purpose, methods, results, and conclusions	Page 2/lines 43-67
Introduction	
Problem formulation - Description and significance of the problem/phenomenon studied; review of relevant theory and empirical work; problem statement	Page 4/ lines 91-101
Purpose or research question - Purpose of the study and specific objectives or questions	Page 4/lines 100-101
Methods	
Qualitative approach and research paradigm - Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., postpositivist, constructivist/ interpretivist) is also recommended; rationale**	Page 7/lines 164-169
Researcher characteristics and reflexivity - Researchers' characteristics that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, and/or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, and/or transferability	Page 6/ lines 140-146
Context - Setting/site and salient contextual factors; rationale**	Page 6/lines 147-150
Sampling strategy - How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling saturation); rationale**	Pages 5-6/ lines 122-139
Ethical issues pertaining to human subjects - Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues	Page 5/ lines 112-116
Data collection methods - Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources/methods, and modification of procedures in response to evolving study findings; rationale**	Page 6-7/ lines 152-159

Data collection instruments and technologies - Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study	Pages 6-7/ lines 152-159
Units of study - Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)	In the results, Page 8/lines 181-182 and Table 1
Data processing - Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and anonymization/de-identification of excerpts	Page 6/ lines 160-162
Data analysis - Process by which inferences, themes, etc., were identified and developed, including the researchers involved in data analysis; usually references a specific paradigm or approach; rationale**	Page 7/lines 163-175
Techniques to enhance trustworthiness - Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationale**	Page 7/ lines 164-175

Results/findings

Synthesis and interpretation - Main findings (e.g., interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory	Pages 8-21/ lines 180-384
Links to empirical data - Evidence (e.g., quotes, field notes, text excerpts, photographs) to substantiate analytic findings	Pages 8-21/ lines 180-384

Discussion

Integration with prior work, implications, transferability, and contribution(s) to the field - Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application/generalizability; identification of unique contribution(s) to scholarship in a discipline or field	Page 22/lines 407-429, Pages 24-25/454-482
Limitations - Trustworthiness and limitations of findings	Page 23/ lines 430-451

Other

Conflicts of interest - Potential sources of influence or perceived influence on study conduct and conclusions; how these were managed	Page 25/line 495-496
Funding – Sources of funding and other support; role of funders in data collection, interpretation, and reporting	Page 1/ lines 22-23

*The authors created the SRQR by searching the literature to identify guidelines, reporting standards, and critical appraisal criteria for qualitative research; reviewing the reference lists of retrieved sources; and contacting experts to gain feedback. The SRQR aims to improve the transparency of all aspects of qualitative research by providing clear standards for reporting qualitative research.

**The rationale should briefly discuss the justification for choosing that theory, approach, method, or technique rather than other options available, the assumptions and limitations implicit in those choices, and how those choices influence study conclusions and transferability. As appropriate, the rationale for several items might be discussed together.

Reference:

O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. **Standards for reporting qualitative research: a synthesis of recommendations.** *Academic Medicine*, Vol. 89, No. 9 / Sept 2014
DOI: 10.1097/ACM.0000000000000388

BMJ Open

An interview study to determine the experiences of cellulitis diagnosis amongst health care professionals in the UK.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-034692.R3
Article Type:	Original research
Date Submitted by the Author:	30-Jul-2020
Complete List of Authors:	Patel, Mitesh; University of Nottingham, ; Lee, Siang Ing; University of Nottingham, Nottingham, UK, Division of Primary Care & National Institute for Health Research, School of Medicine, Levell, Nick; Norfolk and Norwich University Hospital NHS Foundation Trust, Dermatology Smart, Peter; University of Nottingham, Nottingham, UK Kai, Joe; University of Nottingham, Nottingham, UK Thomas, Kim; University of Nottingham, Centre of Evidence Based Dermatology Leighton, Paul; University of Nottingham, Centre of Evidence Based Dermatology
Primary Subject Heading:	Dermatology
Secondary Subject Heading:	Infectious diseases, Qualitative research
Keywords:	DERMATOLOGY, Adult dermatology < DERMATOLOGY, Infectious diseases & infestations < DERMATOLOGY, QUALITATIVE RESEARCH

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Title: An interview study to determine the experiences of cellulitis diagnosis amongst health care professionals in the UK.

Running head: Cellulitis diagnosis by health care professionals

Word count: 3994

Table count: 4

Figure count: 1

Supplementary material: 1

Authors: M Patel, [1,2] S I Lee, [1] NJ Levell, [3] P Smart, [4] J Kai, [1] KS Thomas, [2] P Leighton, [2]

[1] Division of Primary Care & National Institute for Health Research, School of Medicine, University of Nottingham, Nottingham, UK

[2] Centre of Evidence Based Dermatology, University of Nottingham, Nottingham, UK

[3] Dermatology Department, Norfolk and Norwich University Hospital NHS Trust, UK

[4] Patient representative, Centre of Evidence Based Dermatology, University of Nottingham, Nottingham, UK

ORCID ID: M Patel (0000-0003-3975-4689), SI Lee (0000-0002-2332-5452), NJ Levell (0000-0003-3393-8305), J Kai (0000-0001-9040-9384), KS Thomas (0000-0001-7785-7465), P Leighton (0000-0001-5208-0274),

Corresponding author: Mitesh Patel, Division of Primary Care, School of Medicine, University of Nottingham, Nottingham, UK, Email: mpatel59@doctors.org.uk

Funding sources: This study was supported by the Scientific Foundation Board of the Royal College of General Practitioners (grant SFB 2018 – 31).

Study registration: Centre of Evidence Based Dermatology website - https://www.nottingham.ac.uk/research/groups/cebd/documents/researchdocs/protocol-diagnosing-lower-limb-cellulitis-health-care-professionals.pdf

Data sharing: No additional data available

Abstract

Objectives: To explore health care professionals (HCPs) experiences and challenges in diagnosing suspected lower limb cellulitis.

Setting: UK nationwide.

Participants: 20 qualified HCPs, who had a minimum of two years clinical experience as a HCP in the national health service and had managed a clinical case of suspected cellulitis of the lower limb in the UK. HCPs were recruited from departments of dermatology (including a specialist cellulitis clinic), general practice, tissue viability, lymphoedema services, general surgery, emergency care and acute medicine. Purposive sampling was employed to ensure that participants included consultant doctors, trainee doctors and nurses across the specialties listed above. Participants were recruited through: national networks,

HCPs who contributed to the cellulitis priority setting partnership (PSP), UK Dermatology Clinical Trials Network, snowball sampling where participants helped recruit other participants, personal networks of the authors.

Primary and secondary outcomes: Primary outcome was to describe the key clinical features which inform the diagnosis of lower limb cellulitis. Secondary outcome was to explore the difficulties in making a diagnosis of lower limb cellulitis.

Results: The presentation of lower limb cellulitis changes as the episode runs its course. Therefore, different specialties see clinical features at varying stages of cellulitis. Clinical experience is essential to being confident in making a diagnosis, but even amongst experienced HCPs, there were differences in the clinical rationale of diagnosis. A group of core clinical features were suggested, many of which overlapped with alternative diagnoses. This emphasises how the diagnosis is challenging, with objective aids and a greater understanding of the mimics of cellulitis required.

Conclusion: Cellulitis is a complex diagnosis and has a variable clinical presentation at different stages. Although cellulitis is a common diagnosis to make, HCPs need to be mindful of alternative diagnoses.

Keywords: lower limb, cellulitis, diagnosis, health care professionals

Article summary

Strengths and limitations of this study

- The research question was developed from research priorities in the cellulitis priority setting partnership, involving patients.
- Participants were included nationally around the UK.
- Participants from various specialities that commonly diagnose cellulitis were recruited.
- Our recruitment strategy is most likely to have targeted health care professionals with an interest in dermatology.
- The size and scope of the sample population is a limitation.

Introduction

Cellulitis is a frequent presentation in both the community and secondary care, with 60% of presentations affecting the lower limbs.[1] However, the diagnosis of cellulitis can be challenging, with up to a third of suspected lower limb cellulitis cases being later diagnosed as other diagnoses.[2] This results in avoidable hospital admissions and unnecessary antibiotic prescribing [3] and is further compounded by the lack of validated diagnostic criteria or tools for cellulitis.[4]

A UK cellulitis research priority setting partnership (PSP) determined that improving health care professionals' (HCPs) diagnostic accuracy is a key priority for future cellulitis research.[5] An interview study of people with recurrent cellulitis and lymphoedema suggested that patients often experience difficulties in obtaining a speedy and accurate diagnosis. [6]

The aims of this interview study were to explore the HCP experiences and challenges faced in diagnosing suspected lower limb cellulitis.

Methods

Protocol registration and Ethics

The final protocol was registered on the Centre of Evidence Based Dermatology (CEBD) website (9 May 2019). Ethical approval was granted by the Health Research Authority and Health and Care Research Wales (19/HRA/0485) (30 November 2018). Verbal and written consent was obtained from each participant.

Patient and public involvement

The research question was developed from research priorities in the cellulitis PSP, involving patients. A patient representative helped design this study and is a co-author. On publication, participants will be sent the final manuscript.

Eligibility criteria

Selection of participants

Participants were qualified HCPs, who had a minimum of two years clinical experience as a HCP in the national health service (NHS) and had managed a clinical case of suspected cellulitis of the lower limb in the UK. Two years' experience was the minimum requirement as then HCP's will have gained adequate exposure to cellulitis cases. HCPs were recruited from departments of dermatology (including a specialist cellulitis clinic), general practice, tissue viability, lymphoedema services, general surgery, emergency care and acute medicine.

Purposive sampling was employed to ensure that participants included consultant doctors, trainee doctors and nurses across the specialties listed above. Participants were recruited through:

- National networks
- HCPs who contributed to the cellulitis PSP
- UK Dermatology Clinical Trials Network
- Snowball sampling where participants helped recruit other participants
- Personal networks of the authors

Potential participants were approached and recruited by email. Data collection and analysis were undertaken concurrently and sampling ceased when thematic saturation had been achieved (i.e. new interviews generated no new insights).[7]

Researcher characteristics

Interviews were conducted by MP (male), and coded and analysed by MP and SIL (female) (both general practitioner (GP) trainees who had managed clinical cases of cellulitis previously). Both MP and SIL attended qualitative methodology training courses. The broader research group included experienced clinical-academics (JK (academic GP) and NL (clinical professor of

dermatology), a patient representative (PS) and senior qualitative experts (JK and PL). Three participants had clinical interactions with the interviewer in the past, but not regarding cellulitis.

Interview setting

Each participant took part in a single, semi-structured, qualitative interview. Two interviews were face to face, with the remaining via telephone. Written consent was gained from participants, with additional verbal consent gained before the interview. All participants received a £20 reimbursement voucher or donated this fee to the British Skin Foundation charity.

Data collection

Prior to the interview, participants were asked to reflect upon their most recent experiences of making a cellulitis diagnosis, focusing on the typical presentations, challenging cases and differential diagnoses.

A topic guide, informed by a prior systematic review and interview study,[8] was used to structure the interview (Supplementary material). However, participants were urged to propose and/or expand on topics which they felt were relevant to their experience of diagnosis. New topics were then added to the topic guide for subsequent interviews.

Data processing

Interviews were audio-recorded and transcribed. Transcripts were checked (by MP) and data managed using QSR NVivo 12 software.

Data analysis

Analysis was inductive, searching for themes in the data. A structured, systematic, multi-stage approach to thematic analysis was followed.[9] Coders immersed themselves in the data, by reading the data set before coding. Data were coded manually by MP, with SIL also independently coding a third of the transcripts. A list of each code, with a brief description was then used to group the codes into theme-piles. Themes were defined and refined, with sub-themes also developed.

Uncertainties in coding and thematic organisation were resolved in discussion with the other authors. Data collection and analysis was concurrent. The final codebook was agreed by all authors and is presented in Figure 1. The interviewer kept a reflexive research diary, logging intuitive thoughts and immediate reflections after each interview. These reflections, as well as queries around data collection, handling and interpretation were then discussed at regular research meetings.

Results

Twenty HCPs were interviewed (Table 1). The age range was 29-67 years; 15 were female; six had <10 years of clinical experience, nine had 11-20 years and five had >20 years. Interviews were conducted between 19 March and 11 June 2019, with a mean duration of 29 minutes.

Table 1: Characteristics of the participants

Participant	Ethnicity	Clinical role	Number of times they have diagnosed cellulitis	Time since they last diagnosed cellulitis
1	Asian British	GP	>50	One week ago
2	White British	Acute medicine/infectious disease consultant	>50	One week ago
3	White Irish	GP	>50	Three weeks ago
4	White British	Acute medicine consultant	>50	Last four weeks
5	White British	Acute medicine consultant	>50	One week ago

6	White British	Tissue viability nurse	10-50	Less than one week
7	White British	Lymphoedema specialist nurse	>50	One week ago
8	Asian British	Emergency medicine consultant	>50	Less than one week
9	Asian British	Dermatology consultant	10-50	Four weeks ago
10	White British	District nurse	>50	Last three months
11	Black	GP trainee	10-50	Less than one week
12	White British	GP locum	10-50	Two weeks ago
13	White British	GP out of hours	>50	Two weeks ago
14	White British	Dermatology specialist nurse	>50	Last three months
15	White British	Dermatology consultant	10-50	Last 12 months
16	Mixed	Surgical trainee	10-50	Last four weeks
17	White British	Community advanced nurse practitioner	>50	Less than one week
18	White British	Dermatology trainee	>50	Four weeks ago
19	White British	Emergency medicine consultant	>50	Last three months
20	White British	Dermatology consultant	>50	Less than one week

Main findings

Four key themes were identified: 1) The patient presentation; 2) Challenges leading to diagnostic uncertainty; 3) Strategies to improve diagnosis; 4) The need for an objective diagnostic aid, with further classification into sub-themes. How the codes mapped onto the overarching themes are shown in Table 2.

Table 2: How the codes mapped onto themes

Themes	Sub-themes	Codes
The patient presentation	The typical patient and risk factors	• Typical cellulitis presentations
		• Factors that increase the likelihood of cellulitis diagnosis
	Confidence in diagnosis	• Most suitable HCP to diagnose cellulitis •
		• Experience guides diagnosis
	Cases of misdiagnoses	• Missed/delayed diagnosis of cellulitis (final diagnosis)
		• Missed/delayed diagnosis of cellulitis (initial diagnosis)
	Differential diagnoses	• List of alternative diagnosis
Challenges leading to diagnostic uncertainty	Continuum of clinical features	• Changes in clinical presentation
	A subjective diagnosis	• Reasons why cellulitis diagnosis is challenging
	Community challenges	• Seeing patients part way through assessment and management
		• Follow up of patients
	The role of 'defensive' medicine	• Sepsis as a concern
		• Medico legal issues as a factor
		• Fear of missing more serious differentials
	Patient specific factors	• Other factors influencing diagnosis
Strategies to improve diagnosis	Using time as a guide	• Time and safety netting approach
		•
	Trial of treatment	• Trial of treatment guides diagnosis

		•
	Biochemical investigations	• Investigations to aid diagnosis
	Seeking advice	• Discussing diagnosis with colleagues
	Further education	• Suggestions on what may improve diagnosis
The need for an objective diagnostic aid	A diagnostic algorithm	• Views on diagnostic aids for HCP
	Indices for an algorithm	• Clinical features to include in diagnostic algorithm

Diagnosis of cellulitis

The typical patient and risk factors

In general practice, the typical patient described by participants included older adults with co-morbidities; concerns of possible cellulitis cases were often raised by district nursing colleagues. Emergency care and acute services described people who presented with features of systemic compromise. Both infectious disease and general surgery services often managed intravenous drug users who were at risk of deeper infection.

Factors that HCPs stated increased the likelihood of cellulitis were: features of systemic upset including fever, malaise, rigors; co-existing injury or infection such as tinea, superficial ulceration, previous history of cellulitis, previous history of dermatological conditions such as

eczema, diabetes, immunosuppressive medications and those with no fixed abode with social and health risks. Bilateral symptoms were commonly described by participants as a factor increasing the likelihood of chronic, systemic pathologies rather than cellulitis.

Confidence in diagnosis

One dermatologist explained how being more aware of the differential diagnoses made them more likely to accurately diagnose cellulitis, especially compared to junior colleagues. Generally, HCPs with more clinical experience felt more confident with diagnosis, as they appreciated the presentation with more observed cases '*I would say it is just experience [helping diagnosis], a lot of the juniors that come into A&E have not seen that many cellulitis [cases]* (P19, emergency care consultant, 10 years clinical experience).

A dermatology trainee felt seeing less cellulitis cases during their training compared to their senior colleagues historically, and therefore not getting as much exposure, hindered accurate diagnosis.

Cases of misdiagnoses

Trauma related skin changes was frequently an initial misdiagnosis in the emergency department. When discussing cases of uncertainty, where cellulitis was the initial suspected diagnosis, one GP described a case of venous eczema which was managed with repeated antibiotics '*Generally anything that is red and hot on the legs is treated with antibiotics'* (P1, GP, >13 years clinical experience). Chronic rashes were frequently seen by dermatology and infectious disease discussed lymphoma cases initially referred as cellulitis *'We did see [patients] coming in with "Oh this must be a resistant cellulitis", have got a swollen limb that might be a little bit red and it turns out to be some horrible form of lymphoma'* (P2, infectious disease consultant, 25 years clinical experience).

The importance of a correct diagnosis is key, as two participants discussed the possibility of prophylactic antibiotics for patients with recurrent cellulitis. A dermatology consultant explained how misdiagnosis can result in inappropriate and costly admissions to the ward.

Differential diagnoses

A frequent diagnosis of uncertainty for primary and emergency care was deep vein thrombosis (DVT), as the clinical features of cellulitis can overlap *'One thing that is always a problem is leg swelling…it is difficult to ascertain between DVT and cellulitis'* (P8, emergency care consultant,

20 years clinical experience). Common differential diagnoses discussed by participants, which they observed in their clinical practice, with discriminating features from cellulitis that they described, are shown in Table 3.

Table 3: Differential diagnoses of lower limb cellulitis discussed by participants

Differential diagnoses	Key differentiating factors from cellulitis
Chronic heart failure causing oedema	Chronic, bilateral, lack of mobility, breathless, cardiac history (P1,GP;P14,dermatology specialist nurse)
Venous eczema	Usually chronic with hemosiderin scaling, itching, crusting, likely bilateral, possibly eczema elsewhere on body, less well defined, (P3,GP;P15, dermatology consultant)
Thrombophlebitis	Tender, localised, hard, lumpy rash around an often-thickened vein (P3,GP;P5,acute medicine consultant;P12,GP locum)
Erythema nodosum	Multiple, discrete swellings (P13,GP out of hours)
Deep vein thrombosis	Pain is usually deep in calf rather than superficial, less sharply demarcated and less intense erythema, diffuse swelling of limb, can be young, can be intravenous drug users, high DVT wells score, fewer systemic features (P2,infectious disease consultant;P12,GP locum;P13,GP out of hours)

Lymphoedema	Chronic, bilateral, usually less painful, thickened warty skin in the long-term, normal inflammatory markers (P9,dermatology consultant;P18,dermatology trainee)
Allergic reaction to insect bites	Central puncture mark, itch, when acute, developing lichenified erythema when chronic (P2,infectious disease consultant)
Lipodermatosclerosis	Often bilateral, systemically well, tight non tender skin with inverted champagne bottle appearance (P4,acute medicine consultant; P20,dermatology consultant)
Necrotising fasciitis	Crepitus, rapidly spreading, septic, very tender (P5,acute medicine consultant; P16, surgical trainee)
Wound infection	Local to the wound, covers small area, yellow exudate, strong odour (P10,district nurse; P16,surgical trainee)
Baker's cyst	Unilateral popliteal swelling, suddenly more tender on rupture (P15,dermatology consultant)

Challenges leading to diagnostic uncertainty

The continuum of clinical features

Participants described how the presentation of lower limb cellulitis changed as the episode ran its course. This was influenced by when patients seek clinical review and meant that different specialties observed clinical features at varying stages of cellulitis.

In dermatology services, presentations were seen later in the episode. However, partial treatment and response did make the diagnosis challenging as the initial typical features of cellulitis may then vary. However, seeing patients later in the journey allowed dermatologists to appreciate the progression of clinical features '*I learnt to appreciate much more that [cellulitis] is coming up, it is happening and that it is fading away… When I was [junior], I was seeing [cellulitis] at the beginning and middle stages, trying to diagnose it, but in dermatology you're seeing it more at that other end of the spectrum...so I think there is a lot [to be] learnt about seeing that pattern developing and progressing and then resolving'* (P18, dermatology trainee, eight years clinical experience).

Importantly for dermatologists, other more serious pathologies such as a DVT had often been ruled out.

A subjective diagnosis

One GP explained how there is no specific test that can aid diagnosis, thus subjective assessment can lead to different diagnoses *'I think the fact that there is no specific diagnostic test… and two different people can look at [possible cellulitis] and come up with two different answers'* (P1, GP, >13 years clinical experience). She added how this is further influenced by previous experiences, including how long and where HCPs have trained.

Community challenges

In the community, additional challenges for GPs were not being familiar with the patient's background history, seeing a patient for the first time, or taking over care part way through the patient journey. Working as a locum doctor with a lack of follow up available, often led to treatment when unsure of the diagnosis '*You've not met the patient before and sometimes you're not going to be able to follow them up so you probably are more likely to give antibiotics*' (P12, GP locum, seven years clinical experience). Limited resources to see patients, such as not being able to conduct an urgent home visit, also influenced diagnosis and subsequent management by GPs.

The role of 'defensive' medicine

HCPs in the community, emergency care and surgery were particularly wary of missing a more serious diagnosis, which needed to be ruled out first, such as DVT and necrotising fasciitis (NF) '*I think you would want to rule out DVT first because if you miss that then that is… a problem*' (P1, GP, >13 years clinical experience; P16, female, surgical trainee, five years clinical experience). Many HCPs also mentioned '*sepsis*' when discussing clinical features and diagnosis. This may be leading to an over diagnosis of cellulitis due to concerns of medico legal complaints of missing an infection which could then get worse '*We're all risk adverse aren't we? We would rather make sure we weren't sued because we had missed someone with an infection*' (P2, infectious disease consultant, 25 years clinical experience).

Patient specific factors

Participants found people with pigmented skin, lymphoedema and with nonspecific symptoms particularly difficult to diagnose in the acute setting '*One of these classical patients that comes in hasn't got a rash ... [or] the features of swelling, redness, rash and pain in the leg but they come in none specifically unwell ... I think those patients are much trickier [to diagnose cellulitis]*' (P5, acute medicine consultant, 16 years clinical experience). One nurse described another

diagnostic challenge was when a patient presents with chronic skin changes or a recent episode of cellulitis with continuing signs '*People with chronic red [legs], their legs are red most of the time... the skin takes so long to settle, so they could have had cellulitis four weeks ago and it is still red'* (P17, advanced nurse practitioner, 20 years clinical experience).

Strategies used to reduce uncertainty

Using time as a guide

In cases where the HCP was not sure of the diagnosis, different strategies were employed. Using time to allow further clinical features to develop, with appropriate safety netting was a commonly used approach. This was easier when follow-up appointments were available in the community, but was also done in the acute setting '*So if they were well... then I would bring them back to clinic the next day or two*' (P4, acute medicine consultant, 17 years clinical experience). But follow-up in secondary care was difficult, often not done and can be a missed opportunity to learn from incorrect diagnoses previously.

Trial of treatment

Some HCPs started antibiotics for a suspected cellulitis and reviewed the response to help provide the diagnosis retrospectively '*Cellulitis…was the easiest thing to try and treat so I think that definitely pushed [me] to try some antibiotics and see if this is an infection*' (P11, GP

trainee, six years clinical experience). A major concern highlighted by one GP with this approach was antibiotic resistance and side effects. However, overall, there was a common understanding in primary care why this approach was taken in some instances.

Biochemical investigations

In primary care, one doctor described how blood tests and cultures were rarely done to diagnose cellulitis, as such patients would need to be seen in secondary care. Blood cultures were requested by the infectious disease physician if it was an atypical infection, but a challenge described by one dermatology consultant was that organisms are not isolated in the majority of patients. Swabs were done for discharging wound infections, mainly by district nurses or prior to discussion with microbiology, when see by dermatologists.

An emergency physician and surgical trainee explained how blood tests and imaging such as x-rays are important to check for osteomyelitis. The blood tests commonly requested by secondary care HCPs were white cell count (WCC) and C-reactive protein (CRP) for infection with one dermatologist stating how changes in blood test results were important when taking referrals for suspected cellulitis '*[With cellulitis]...you expect a) it is unilateral, b) you want some inflammatory markers which are raised, at least a reasonable WCC and CRP and if it is normal*

it is not going to be cellulitis' (P9, dermatology consultant, 10 years clinical experience). However, one challenge with interpreting blood tests was in the group partially treated with antibiotics, who have improving blood tests but limited clinical response. A biomarker or point of care test for cellulitis were suggested as investigations to aid diagnosis by one dermatology consultant and one GP respectively.

Seeking advice

Another approach during uncertainty was to discuss with colleagues. In the community the nurse may ask the GP to review and vice versa. In hospital, specialists in infectious disease, dermatology, microbiology and general/plastic surgeons are most often contacted for review.

Further education

Many HCPs mentioned teaching sessions to improve diagnosis, both at the undergraduate and postgraduate level. One GP stated that real life clinical cases were felt to be important for teaching, rather than focusing on pictures '*It is all very well seeing pictures but pictures aren't that helpful sometimes, it is how it feels sometimes that makes a difference and actually seeing it in the flesh is very different to seeing even good quality pictures, so I do think that clinical exposure [is important]* (P13, GP, 20 years clinical experience).

A dermatology consultant suggested that a key area of education amongst HCPs was being aware of differential diagnoses for frontline services '*It is not something people will have put a lot of thought into, the differentials, and I think the focus needs to be on teaching the frontline staff* (P15, dermatology consultant, 18 years clinical experience).

One trainee who worked in a specialist cellulitis clinic found that seeing many cases helped improve her recognition of cellulitis.

The need for an objective diagnostic aid

A diagnostic algorithm

Many participants mentioned developing a diagnostic algorithm, similar to the Wells score for DVT. A GP explained how this may also help GPs make a validated clinical decision when colleagues such as district nurses are suspecting cellulitis and the patient cannot be seen quickly. A dermatology nurse described how she often used checklists and how an algorithm would help HCP's not to miss any clinical features *'[A checklist] could help people that weren't experienced or confident enough…it just gives you something to think about like "oh I hadn't thought about the heat'"* (P14, dermatology nurse, nine years clinical experience).

One dermatology consultant suggested that a diagnostic checklist should be more of an educational tool to help rule out other differential diagnoses '*For a diagnostic checklist you almost want it to be provided as an education tool with photographs and descriptions... so that people can put these differential diagnoses into their head* (P15, dermatology consultant, 18 years clinical experience).

A dermatology trainee felt that the indices of a checklist would have to reflect how cellulitis changes through the course of the episode. Other challenges described by participants, regarding developing an algorithm were the number of alternative diagnoses, with features that often overlapped with cellulitis and vague initial features. Another concern highlighted by a dermatology consultant was that algorithms will miss patients who may present with atypical features '*Sometimes the trouble with guidelines, algorithms... you could probably cover 95% but does it mean that actually the atypical 5% then [do not] get diagnosed?* (P20, dermatology consultant, 42 years clinical experience).

Indices for an algorithm

The key clinical features HCPs suggested to include in a diagnostic algorithm for lower limb cellulitis were: unilateral, pain, erythema, warmth of limb, pyrexia, swelling, acute onset, trauma

to the limb, break in the skin, single area affected, clear demarcation, exudate, flu like malaise, tracking rash, shiny, tenser skin, previous cellulitis, co-existing immunosuppression, co-existing skin conditions, clinical observations for sepsis, negative Wells score and patient concern. No HCP suggested blood tests were a priority in the algorithm, but a GP trainee suggested it could be included in a modified algorithm in secondary care, similar to the CURB-65 score used for pneumonia.

Additional quotes from participants are shown in Table 4.

Table 4: Additional quotes from participants, grouped into themes and subthemes

Themes	Subthemes	Participant quotes
The patient presentation	**Confidence in diagnosis**	'*I probably thought more presentations were [cellulitis] as a junior doctor… I probably didn't really recognise that sort of stretched skin appearance.. I think that has come along as part of just experience over the years, so I probably diagnosed more cellulitis inappropriately as a more junior doctor*' (P13, GP out of hours, 20 years clinical experience)
	Cases of misdiagnoses	'O*ne of the nurse practitioners had seen ankle swelling and the patient thought it… he played some cricket two or three days ago and after one or two days the swelling appeared and she thought that it was just a sprain but next day he represented, I saw him and it looked more like cellulitis because it was quite red, localised area… on close examination I could see a couple of scratches around the ankle so that was maybe the source of cellulitis spreading on the leg'* (P8, emergency care consultant, 20 years clinical experience)

		'*There are too many chronic rashes that get referred [to dermatology] as cellulitis*' (P18, dermatology trainee, eight years clinical experience)
Challenges leading to diagnostic uncertainty	**Continuum of clinical features**	'*Usually the patient is already admitted ... [the referring team] have tried [multiple antibiotics], but nothing is happening, "please can you come and tell us what is going on?"*' (P9, dermatology consultant, 10 years clinical experience) '*There are varying ranges of erythema, from a little bit of light pinkness to rip roaring hot red, tender, well demarcated, unilateral; the classic sort of textbook stuff* (P18, dermatology trainee, eight years clinical experience) '*Virtually every patient that I see...they have had their d-dimer and their duplex done so [DVT] is usually a diagnosis that has been excluded* (P20, dermatology consultant, 42 years clinical experience)
	Community challenges	'*If you know the patient and you know that they have recurrent cellulitis, someone had seen it like a district nurse and it is Friday afternoon and you can't get out [for a visit].. you would make a judgement call* (P1, GP, >13 years clinical experience)
	The role of 'defensive' medicine	'*We're so much more aware of things like sepsis… looking at any kind of signs of infection*' (P10, district nurse, 25 years clinical experience)
Strategies to improve diagnosis	**Using time as a guide**	'*All you can really do is reassure the patient and say…I don't see any clear evidence of cellulitis but we will keep an eye on it... you give safety net advice to the patients'* (P18, dermatology trainee, eight years clinical experience)
	Trial of treatment	'[*My concerns with this approach] are antibiotic resistance and side effects…especially in older groups...I would say probably that is not the best approach'* (P3, GP, 18 years clinical experience)
	Biochemical investigations	'*If I am thinking about doing blood tests…it is unlikely that I am going to continue managing them in the community*' (P11, GP trainee, six years clinical experience)

		'*I would never not diagnose somebody [with cellulitis] just because their inflammatory markers are normal* (P5, acute medicine consultant, 16 years clinical experience)
	Further education	*'You very quickly just get entrenched in…your preferences for diagnoses and it is often good to refresh*' (P11, GP trainee, six years clinical experience) '*I only did two weeks [of dermatology] as a medical student… but certainly increasing dermatology teaching at an earlier stage would make a massive difference'* (P13, GP, 20 years clinical experience). '*Pattern recognition and [seeing] variation in the progression of the rash [are important]*', thereby appreciating the '*life of rashes*' (P18, dermatology trainee, eight years clinical experience).
The need for an objective diagnostic aid	**A diagnostic algorithm**	'*I think it can be helpful to have those objective measures [of an algorithm], if it was accepted and validated as a reasonable measure of cellulitis, I think I would actually use that*' (P11, GP trainee, six years clinical experience). '*You would have to develop a criteria that can pick up the beginning, it is in the middle and it is resolving at the end*' (P18, dermatology trainee, eight years clinical experience). '*Because there is such a wide differential…how would you exclude all of those and also it can be quite nonspecific sometimes in the early stages*' (P12, GP locum, 7 years clinical experience).

Discussion

Summary

This study found that the presentation of lower limb cellulitis changes as the episode progresses, leading to variation in the clinical features, seen in different clinical settings. This may be reflected in the range of typical differential diagnoses that specialities discussed and has been described in literature.[10]

Clinical experience was described as an important factor in making a more accurate diagnosis. Dermatologists have previously been suggested as the ideal HCP to diagnose cellulitis.[11] However, the clinical reasoning behind a diagnosis were contradictory between some HCPs.

A core group of clinical features to diagnose cellulitis were suggested. But the challenge is that these features can overlap with other pathologies, irrespective of how likely these are.[12] More serious pathologies then need to be ruled out first, both for the safety of the patient and to avoid medico-legal consequences.

Suggestions to improve the accuracy of diagnoses included developing a diagnostic algorithm which could objectively help HCPs with different levels of experience.[13] The challenge with a diagnostic algorithm is that it would need to incorporate the various stages of a cellulitis episode and therefore various versions of an algorithm might be required.

Importantly, having a greater understanding of the alternative diagnoses is required, especially when the features are vague, atypical or not responding to antibiotic treatment. Educating both doctors and nurses, using real life clinical scenarios and a focus on differential diagnoses, was also discussed and may be an initial feasible approach to improve diagnostic accuracy. A visually based computerized diagnostic decision support system, focusing on differential diagnoses, has been shown to improve the diagnostic accuracy of cellulitis. [14]

Strengths and limitations

A key strength of this study that participants were included nationally around the UK, across various specialities that commonly diagnose cellulitis, with both nurses and doctors of varying clinical experience.

Like similar studies, the size and scope of the sample population is a limitation of this work. Whilst we argue that our findings are transferable to other settings, we acknowledge that those

interviewed were perhaps more interested and better informed about dermatology than many HCPs. This was a function of our purposive sampling, and the likelihood that those interested in cellulitis were more likely to consent to an interview. Furthermore, the participants in this study were mainly female doctors. This may not be representative of the workforce in non-UK countries; therefore the transferability of our findings may be limited.

Some participants were unable to fully describe their clinical rationale behind diagnostic decisions during the interview. This may be because they have developed an intuitive, pattern-recognition, approach in decision-making with experience. Such heuristic diagnostic processes in dermatology are well documented. [15]

As the interviewer was a fellow clinician, interviewees may not have fully shared the details of cases that were misdiagnosed or where diagnoses were delayed due to social desirability bias or fear of litigation. Clinical researcher bias was unavoidable, as the interviewer had clinical insight into cellulitis. However, non-clinicians within the broader authorship group were also involved with coding and analysis of the interviews.

Three participants were known to the interviewer, which can lead to response bias, however the interviewer felt this also allowed an honest, open discussion.

Comparison with existing literature

To our knowledge, this is the first interview study undertaken with health care professionals, discussing their experiences of cellulitis diagnosis. Our findings on the clinical features of cellulitis, differential diagnoses and also the need to be aware of mimics have been described in previous review articles.[10] A previous review also described cases of misdiagnosis and emerging approaches to improve diagnoses, [8,16] which were echoed in this study. The diagnostic challenges of infection in primary care, due to atypical presentations and lack of diagnostic tests has previously been described.[17] Using treatments such as antibiotics as diagnostic aids and discussing with colleagues when uncertain about a diagnosis are common strategies. [18,19] Litigation and fear missing a diagnosis has also been well documented in literature. [20]

Implications for research and practice

This study has highlighted that HCPs need to be aware that cellulitis can present with different features at various stages of the acute episode and need to consider the cellulitis mimics. With

a current shift in health care resulting in trained nurses now managing more acute presentations, [21] upskilling nurses in cellulitis could be part of the solution.

Many HCPs felt confident in making an accurate diagnosis, often guided by experience and intuition, but found it difficult to verbalise the key distinguishing features. This makes it difficult for the clinical experience to be shared amongst other colleagues, especially less experienced or junior HCPs. Acquiring this insight is important to improve diagnostic accuracy, which can prevent avoidable antibiotic prescribing and hospital admissions. To overcome this, further qualitative research is required to identify the clinical reasoning behind the expert process of making a diagnosis, perhaps using clinical cases and pictures. This will form the basis of the proposed solution of focused education and clinical features to be included in a diagnostic aid. The challenge with further education for HCPs is that information needs to be accessible for everyone, whilst information overload can lead to a reduction in the quality of decisions. [22]

Some indices and risk factors for a diagnostic algorithm have been identified in this study and previous studies, [23] as well as key distinguishing features from differential diagnosis, but these need validating with larger studies and an expert consensus setting exercise.

Conclusion

This interview study has shown that cellulitis is a complex diagnosis. Not only does the core features overlap with other diagnoses, the presentation of cellulitis changes as the episode progresses. Although cellulitis is a common diagnosis to make, and whilst further research in developing diagnostic aids needs to be undertaken, simply being aware of the cellulitis mimics may help improve diagnostic accuracy.

Acknowledgements

We would like to thank the participants who were interviewed and the professional transcriber Claire Pox on. We also want to thank the Royal College of General Practitioners for supporting this study. The views expressed in this paper are those of the authors and not necessarily those of the National Health Service, the National Institute for Health Research or the Department of Health.

Competing interest

None declared

Author contributions

M Patel was involved with the design of the study, collection and analysis of data, drafting the manuscript and final approval of the manuscript.

S I Lee was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

NJ Levell was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

P Smart was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

J Kai was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

KS Thomas was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

P Leighton was involved with the design of the study, analysis of data, drafting the manuscript and final approval of the manuscript.

References

1 Lazzarini L, Conti E, Tositti G, et al. Erysipelas and cellulitis: clinical and microbiological spectrum in an Italian tertiary care hospital. *J Infect* 2005; **51**(5):383-9.

2 Weng QY, Raff AB, Cohen JM, et al. Costs and Consequences Associated With Misdiagnosed Lower Extremity Cellulitis. *JAMA Dermatol* 2017; **153**(2):141–146.

3 David CV, Chira S, Eells SJ et al. Diagnostic accuracy in patients admitted to hospitals with cellulitis. *Dermatol Online J* 2011 ; **17**(3):1.

4 Patel M, Lee SI, Akyea RK, et al. A systematic review showing the lack of diagnostic criteria and tools developed for lower limb cellulitis. In print: *Br J Dermatol* 2019.

5 Thomas KS, Brindle R, Chalmers JR, et al. Identifying priority areas for research into the diagnosis, treatment and prevention of cellulitis (erysipelas): results of a James Lind Alliance Priority Setting Partnership. *Br J Dermatol* 2017; **177**:541-543.

6 Patel M, Lee SI, Levell NJ, et a. Confidence of recurrent cellulitis self-diagnosis among people with lymphoedema: a qualitative interview study. *Br J Gen Pract 2020*; 70(691).

7 Guest G, Bunce A, Johnson L. How many interviews are enough? An experiment with data saturation and variability. *Field Methods* 2006; 18(1): 59–82.

8 Patel M, Lee SI, Thomas KS, Kai J. The red leg dilemma: a scoping review of the challenges of diagnosing lower-limb cellulitis. *Br J Dermatol* 2019; **180**: 993-1000.

9 Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol* 2006; **3**: 77-101.

10 Bailey E, Kroshinsky D. Cellulitis: diagnosis and management. *Dermatol Ther 2011*; **24**(2):229-239.

11 Levell NJ, Wingfield CG, Garioch JJ. Severe lower limb cellulitis is best diagnosed by dermatologists and managed with shared care between primary and secondary care. *Br J Dermatol 2011;* **164**(6):1326-8.

12 Raff AB, Kroshinsky D. Cellulitis: A Review. *JAMA 2016;* **316**(3):325-37.

13 Pallin DJ, Bry L, Dwyer RC, et al. Toward an Objective Diagnostic Test for Bacterial Cellulitis. *PLoS One 2016*; **11**(9):e0162947.

14 David CV, Chira S, Eells SJ et al. Diagnostic accuracy in patients admitted to hospitals with cellulitis. *Dermatol Online J* 2011; **17**(3):1.

15 Lowenstein EJ. Dermatology and its unique diagnostic heuristics. *JAMA Dermatol* 2018; **78**(6):1239-1240.

16 Edwards G, Freeman K, Llewelyn MJ, Hayward G. What diagnostic strategies can help differentiate cellulitis from other causes of red legs in primary care? *BMJ 2020*; **368**:m54.

17 McKelvie S. Moore A, Croxson C, et al. Challenges and strategies for general practitioners diagnosing serious infections in older adults: a UK qualitative interview study. *BMC Fam Pract 2019;* **20(**56).

18 Hayward GN, Moore A, Mckelvie S, et al. Antibiotic prescribing for the older adult: beliefs and practices in primary care. *J Antimicrob Chemother 2019*;74(3):791-797.

19 Alam R, Cheraghi-Sohi S, Panagioti M, et al. Managing diagnostic uncertainty in primary care: a systematic critical review. *BMC Fam Pract 2017*;**18**(1):79.

20 Birks Y, Aspinal F, Bloor K. Understanding the drivers of litigation in health services. The Kings Fund 2018. University of York.

21 Imison C, Castle-Clarke S, Watson R. Reshaping the workforce to deliver the care patients needs. Research Report. 2016. Nuffield Trust.

22 Kumar A, Maskara S. Coping up with the Information Overload in the Medical Profession. *J Biosci Med 2015*; **3**(11):214-127.

23 Quirke M, Ayoub F, McCabe A, et al. Risk factors for nonpurulent leg cellulitis: a systematic review and meta-analysis. *Br J Dermatol 2017*;**177**(2):382-394.

Figure 1: Standardised codebook used by two independent coders

Supplementary Material

Topic guide used to structure the interview

Codes used

- Trial of treatment guides diagnosis
- Discussing diagnosis with colleagues
- Time and safety netting approach
- Patients who self-diagnose and treat
- Approach when HCPs do not agree with patient self-diagnosis
- Patients involved with diagnosis with the HCP
- Typical cellulitis presentations
- Clinical features of cellulitis
- Factors that decrease the likelihood of cellulitis diagnosis
- Factors that increase the likelihood of cellulitis diagnosis
- Investigations to aid diagnosis
- Missed/delayed diagnosis of cellulitis (final diagnosis)
- Missed/delayed diagnosis of cellulitis (initial diagnosis)
- Patient finds it difficult to accept it is not cellulitis
- Reasons why cellulitis diagnosis is challenging
- Suggestions on what may improve diagnosis
- Views on diagnostic aids for HCP
- Views on diagnostic aids for patients
- Views on how well HCP make diagnosis
- Experience guides diagnosis
- Seeing patients part way through assessment and management
- Differential diagnoses
- Sepsis as a concern
- Medico legal issues as a factor
- Follow up of patients
- Most suitable HCP to diagnose cellulitis
- Fear of missing more serious differentials
- Clinical features to include in diagnostic algorithm
- Other factors influencing diagnosis

If the participant has a recent case of cellulitis that they can discuss:

Can you tell me about a case of cellulitis that you diagnosed?

Prompts:

- What thoughts go through your head when you are considering a diagnosis of cellulitis?
- What symptoms do you ask about? Local? General?
- What signs do you look for? Local? General?
- Are there any specific signs/symptoms you rely on to help?
- Did you do any tests?
- Did you seek advice from anyone else?
- Were you concerned that this may not be cellulitis?
- If you were concerned, why?
- Was there anything challenging about this case?
- How did you address these challenges?
- How confident were you that this was cellulitis on a 1-10 scale when you first saw the patient?
- Did the patient discuss any self-diagnoses?
- Did any external factors such as time influence your decision?
- Did the patient come back to see you again?
- Would you change your approach if the same case presented again?
- Is this a typical case you see?
- What are the main differential diagnoses you see?

Repeat the above for a maximum two cases that the participants may have for the interview (repeat twice only if the participant has no delayed/incorrect cases below).

If the participant has a case where the diagnosis was delayed or incorrect (can be initially either seen by same health care professional or a colleague, but preferably the same person)

Prompts:

- Did you see the patient on initial presentation or was it a colleague?
- If it was another colleague, what specialty did they work in?
- What symptoms did they present with?
- What signs did they have?
- What was the initial diagnosis? And why?
- Were any tests done?
- Did any external factors influence the decision for the initial diagnosis?
- When did they see you or another colleague again?
- If it was another colleague, what specialty did they work in?
- Did anything change with the signs/symptoms?
- What happened next?
- Do you know what the final diagnosis was?
- What were the reasons for the delay in the diagnosis?
- Why was it difficult to make an accurate diagnosis on first consultation?

We want to establish if it is possible to determine a core group of features that can be used to help diagnose lower limb cellulitis

Prompts:

- What symptoms are you asking about?

- Of these symptoms, which do you think are more suggestive of cellulitis?
- Are there any symptoms that make cellulitis less likely?
- Are there other features in the history which make cellulitis more/less likely? (prompt – other conditions, previous history, drugs, family history)
- What signs are you looking for?
- Of these signs, which do you think are more suggestive of cellulitis?
- Would you request any tests if it was available to you on the same day?
- If so what tests would these be?
- Are there any signs in a 'red leg' that would make cellulitis less likely as the diagnosis?
- Are there any signs in a red leg which would make cellulitis more likely as the diagnosis?
- How has your approach to diagnosing cellulitis changed after managing previous cases?
- If the patient has had previous cellulitis, does this influence your diagnosis?
- From your experience, what differential diagnoses do you think about?
- How do you distinguish cellulitis from these differential diagnoses?
- Specifically, how do you differentiate cellulitis from lymphoedema?
- Specifically, how do you differentiate cellulitis from venous eczema?
- Specifically, how do you differentiate cellulitis from infected venous eczema?
- Specifically, how do you differentiate cellulitis from lymphodermatosclerosis?
- Do you feel that a list of key diagnostic features of cellulitis would help when assessing patients?

We want your views on some aspects of diagnosis that patients with recurrent cellulitis and lymphoedema have discussed

- Patients felt that they were confident in making a self-diagnosis of cellulitis and valued greater trust in self-management at home with treatment. What are your thoughts on patients self-diagnosing?
- Would a photograph with a proforma taken and filled in by the patient and sent to you be helpful in managing patients with recurrent cellulitis?
- In the instance where you may not agree with the patients self-diagnosis of cellulitis, how would you manage the diagnosis?
- Do you feel that any further training or resources should be set up to help improve our diagnosis of cellulitis? For example as specialist cellulitis clinic to refer patients to?
- What are your thoughts on health care professionals having a guide such as checklist to help diagnosis?
- Do you think patients should have this checklist? If so why or why not?

Standards for Reporting Qualitative Research (SRQR)*

http://www.equator-network.org/reporting-guidelines/srqr/

	Page/line no(s).
Title and abstract	
Title - Concise description of the nature and topic of the study Identifying the study as qualitative or indicating the approach (e.g., ethnography, grounded theory) or data collection methods (e.g., interview, focus group) is recommended	Page 1/line 1-2
Abstract - Summary of key elements of the study using the abstract format of the intended publication; typically includes background, purpose, methods, results, and conclusions	Page 2/lines 43-67
Introduction	
Problem formulation - Description and significance of the problem/phenomenon studied; review of relevant theory and empirical work; problem statement	Page 4/ lines 91-101
Purpose or research question - Purpose of the study and specific objectives or questions	Page 4/lines 100-101
Methods	
Qualitative approach and research paradigm - Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., postpositivist, constructivist/ interpretivist) is also recommended; rationale**	Page 7/lines 164-169
Researcher characteristics and reflexivity - Researchers' characteristics that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, and/or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, and/or transferability	Page 6/ lines 140-146
Context - Setting/site and salient contextual factors; rationale**	Page 6/lines 147-150
Sampling strategy - How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling saturation); rationale**	Pages 5-6/ lines 122-139
Ethical issues pertaining to human subjects - Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues	Page 5/ lines 112-116
Data collection methods - Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources/methods, and modification of procedures in response to evolving study findings; rationale**	Page 6-7/ lines 152-159

Data collection instruments and technologies - Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study	Pages 6-7/ lines 152-159
Units of study - Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)	In the results, Page 8/lines 181-182 and Table 1
Data processing - Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and anonymization/de-identification of excerpts	Page 6/ lines 160-162
Data analysis - Process by which inferences, themes, etc., were identified and developed, including the researchers involved in data analysis; usually references a specific paradigm or approach; rationale**	Page 7/lines 163-175
Techniques to enhance trustworthiness - Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationale**	Page 7/ lines 164-175

Results/findings

Synthesis and interpretation - Main findings (e.g., interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory	Pages 8-21/ lines 180-384
Links to empirical data - Evidence (e.g., quotes, field notes, text excerpts, photographs) to substantiate analytic findings	Pages 8-21/ lines 180-384

Discussion

Integration with prior work, implications, transferability, and contribution(s) to the field - Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application/generalizability; identification of unique contribution(s) to scholarship in a discipline or field	Page 22/lines 408-429, Pages 24-25/454-482
Limitations - Trustworthiness and limitations of findings	Page 23/ lines 430-451

Other

Conflicts of interest - Potential sources of influence or perceived influence on study conduct and conclusions; how these were managed	Page 25/line 495-496
Funding – Sources of funding and other support; role of funders in data collection, interpretation, and reporting	Page 1/ lines 22-23

*The authors created the SRQR by searching the literature to identify guidelines, reporting standards, and critical appraisal criteria for qualitative research; reviewing the reference lists of retrieved sources; and contacting experts to gain feedback. The SRQR aims to improve the transparency of all aspects of qualitative research by providing clear standards for reporting qualitative research.

**The rationale should briefly discuss the justification for choosing that theory, approach, method, or technique rather than other options available, the assumptions and limitations implicit in those choices, and how those choices influence study conclusions and transferability. As appropriate, the rationale for several items might be discussed together.

Reference:

O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. **Standards for reporting qualitative research: a synthesis of recommendations.** *Academic Medicine*, Vol. 89, No. 9 / Sept 2014
DOI: 10.1097/ACM.0000000000000388